SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, JANUARY 4, 1907

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FACT AND THEORY IN SPECTROSCOPY[1]

BEFORE passing to some present problems in physics, let us pause a moment to consider the losses which our science has sustained since the last annual meeting.

The life and work of Professor Langley, who died on the twenty-seventh of February last, will long continue to form an important chapter in the history of astrophysics. To the study of this science he brought rare skill, perseverance and clearness of purpose. Among his most important contributions is to be mentioned his epoch-making determination of the distribution of energy through the spectra of various sources, including especially the sun, moon and firefly. His measurement of the lifting power of an aeroplane driven at a definite angle with a definite speed, his exquisite discussion of the 'Internal Work of the Wind' with its accompanying explanation of soaring and his still later achievement of actual flight are matters which have perhaps only recently received fair appreciation. The recent performance of the Wright brothers in Ohio and the flight of Santos Dumont in a 'manned' machine are but two events in the logical series which Professor Langley did much to initiate.

On the nineteenth of April, 1906, occurred a great tragedy. Nothing in the behavior of that remarkable element which

[1] Vice-presidential address before Section B of the American Association for the Advancement of Science, New York, December 28, 1906.

he helped to discover can be considered more unexpected or more inexplicable than the death of Professor Pierre Curie.

The manner in which the clew given by uranium rays was taken up and followed out with persistent endeavor, clearness of vision, simplicity of life and modesty of character, has been rarely paralleled in the history of physics.

Our admiration for his scholarship and for his generous chivalric nature is united with a keen sense of loss to science and a warm sympathy for his brilliant and loyal comrade.

On the fifth of July, last, Germany and the rest of the world suffered a deplorable and inexplicable loss in the death of Professor Paul Drude. Brilliant and numerous as his achievements were, it is difficult to believe that his work was more than half done. Perhaps no better illustration of his genius can be found than in the beautiful manner in which he has quantitatively connected the subjects of thermal and electric conductions, on the basis of the electron theory; while his two splendid volumes have rendered all students of physics his debtors.

The death of Boltzmann, two months later, was an equally great mystery. The most valuable work of this remarkable and somewhat bizarre character undoubtedly lies in the field of the kinetic theory of gases.

His treatise on this subject constitutes for me—I confess it freely, but sadly—a sealed volume. Were I to attempt to convey to you any idea of its importance I should feel, only in a much truer sense, what Boltzmann himself expresses in the preface of his wonderfully lucid exposition of Maxwell's electromagnetic theory, when he quotes from 'Faust.'

> "So soll ich denn mit saurem Schweiss,
> Euch lehren was ich selbst nicht weiss."

Boltzmann's two visits to America, one in 1898 and one in 1904, were full of interest for many of the members of this section. Suffice it to say that some of his colleagues have expressed the opinion that since the death of Helmholtz, Boltzmann has been the leading physicist of Germany.

I beg now to call your attention to a matter which seems to me somewhat intimately connected with spectroscopic progress. And one can perhaps do this most simply by first offering a definition of spectroscopy; secondly, stating what may be considered the fundamental facts of the science; and, thirdly, considering to what extent these facts—for one hesitates even yet to call them 'principles'—are explained by any general theory of the subject.

Any explanation of light which is general and satisfactory may be said to include at least two chapters, namely, one which shall explain the transmission of radiation and another which shall treat of the origin or production of radiation. The first chapter treats of the electromagnetic ether; the second treats of matter which is at once 'the source and recipient of radiation.'

It was in the autumn of 1888 that the experiments of Hertz in a certain sense closed the chapter on the transmission of light, a large part of which had been written by Maxwell in 1864. Since then, the second portion of the theory—that dealing with the radiant atom—has assumed larger importance. Any treatment of the production of radiation falls more or less naturally into three parts, namely, (1) the radiation of solid and liquid bodies which is almost, but not quite, independent of atomic structure; (2) the radiation which takes its rise in radioactive substances and which is apparently dependent upon atomic collapse; and (3) the radiation of gaseous substances, dependent almost entirely upon normal atomic structure, and possibly also upon the mode of excitation.

The subject to which your consideration is invited has to deal only with radiation of this third class. Radiation which in terms of the electron theory is said to be due not to abrupt or discontinuous acceleration but to periodic acceleration.

DEFINITION OF SPECTROSCOPY

The science of spectrum analysis which was born, one might almost say, in Bunsen's laboratory in 1859, developed within a period of four or five years into a science of a totally different character, a science which enabled Kirchhoff at once to study the physical structure as well as the chemical constitution of the sun, a science which permitted Huggins as early as 1864 to distinguish between star clusters and nebulæ, a science much wider than spectrum analysis, a branch of learning which we now call spectroscopy. Briefly defined, it is that science which has for its object the general description of radiation, including the production of radiation, the analysis of radiation, the registration of radiation and the measurement of radiation.

The theory of separating, recording and comparing radiation is by no means simple or complete. That these last three operations demand in practise the highest degree of skill is exemplified by the work of Rayleigh, Rowland, Michelson, Perot and Fabry, and Hale.

There is, however, a certain very true sense in which these last three processes are merely preparatory to a more profound study of the first, namely, the production of radiation. From this point of view, spectroscopy hinges upon the radiant atom —if there be an atom—and may be defined imperfectly and narrowly perhaps as *the science of the radiant atom.*

More than one brilliant and partially successful attempt has been made within the last quarter century to establish an adequate foundation for this science by devising what may be called a satisfactory atom. But before considering any of these attempts it may be well to state briefly what seem to be the criteria by which any such foundation is to be judged.

Perhaps it may be fair to consider that atom as most competent which will explain satisfactorily the largest number of the following nine facts.

CRITERIA

1. The fact that spectral lines are in general approximately sharp.

2. The fact that spectral lines are never perfectly sharp; but always have a finite physical width.

3. The fact that certain spectral lines are arranged in series and bands after the manner described so perfectly by Balmer's equation and its generalized forms.

4. The fact that increase of pressure causes a shift of spectral lines toward the red as discovered by Humphreys and Mohler.

5. The fact that a magnetic field will transform single lines into multiple polarized lines as discovered by Zeeman.

6. We come now to a group of phenomena which are not easily described under a single caption. I refer to phenomena such as those observed by Plücker and Hittorf, when they found one and the same gas in one and the same tube yielding very different spectra according to the mode in which the electric discharge was applied to make the gas luminous. In the same category doubtless belongs the extinction of air lines by the insertion of self-induction into the discharge circuit. Here may belong also the fact studied by Lenard and others that the region near the electrode of an arc gives a spectrum different from the region near the center of the arc; the fact also that the so-called 'spark lines' are introduced into an arc by reducing the current to small values, a fact first studied by Hartmann.

And certainly in this same category belongs the fact that the spectrum of an arc is modified when the arc is surrounded by an atmosphere different from ordinary air.

Here also lie the profound differences between arc and spark spectra of the same element.

Notwithstanding the fact that 'multiple spectra' is a term which has hitherto been employed to describe the Plücker tube variations, I propose that we generalize it and use it to describe this entire group of facts. Since the name is so appropriate, let us call the sixth fundamental phenomenon that of 'multiple spectra.'

7. Any competent atom must allow us to infer the relations which have been proved to exist between spectral phenomena and atomic weights.

8. The phenomena of line reversals and absorption bands.

9. The fact that heat alone, at least within the range of our highest artificial temperatures, produces characteristic spectra in only a few rare instances.

These, briefly, are the parts of the spectroscopic superstructure for which a foundation is sought. These are the various parts which it is hoped will, some day, be cemented together, by a simple and general theory, into a harmonious structure.

But there is a final criterion, even more fundamental than any of those which have been mentioned, that such a theory must satisfy, namely, this hypothetical radiant atom must not in its behavior, except as a very last resort, contradict any of the established principles of physical science, be they mechanical, electrical or chemical.

The principle of the conservation of energy must be satisfied even if it is necessary to assign an undreamed of amount of energy to each atom; in like manner Newton's third law is to be satisfied, even if the electromagnetic ether is called upon to furnish the reaction.

But even with this added criterion, the preceding list of nine phenomena is confessedly incomplete; the only object of such a catalogue is to include those typical fundamental facts which ought, apparently, to follow as immediate consequences from the structure of the radiating body, so soon as that structure is correctly guessed. Thus Doppler's principle is omitted on the ground of its being rather a kinematic law, governing periodic disturbances in any medium, than a dynamical fact to be explained in terms of atomic structure and forces.

THE SATURNIAN ATOM

Having established a set of criteria by which we may estimate the fitness of a radiant atom, it would be interesting, if I were competent, and if time permitted, to pass in review some of the various atoms which have been proposed in recent times; such as that of Kelvin, 1884, or those suggested by the Hertzian oscillator.

But neither of these two conditions is fulfilled, and I propose, therefore, to consider only one atom, namely, the one which by common consent, I think I may safely say, comes more nearly satisfying the demands of experimental fact than any other ever devised. I refer to the atom first proposed in a general way by Lord Kelvin in his paper entitled 'Epinus Atomized,'[2] and afterwards profoundly modified by Lorentz, Thomson and Larmor.

So much work along this line has been done in the Cavendish Laboratory that one feels impelled to call this 'the Cambridge atom'; in view, however, of its structure, perhaps 'the Saturnian atom' is a more appropriate designation.

Now as to the proper conception of the normal Saturnian atom—I am not certain that I know what this is, but my mental

[2] Baltimore Lectures, p. 541 (Cambridge, 1904).

picture of it is somewhat like the following:

1. Conceive a single negatively charged electron—whatever that may be—placed inside a mass of positive electrification—whatever that may be. On the basis of the Zeeman effect, we may imagine this electron to be revolving about the center of the positive charge; and we may assume its rate of revolution such that it is in equilibrium under the first-power-of-the-distance law.

But even if we did not have the Zeeman effect to suggest rotation we should be compelled, as Jeans[3] has shown, to introduce rotation, on the basis of Earnshaw's theorem, to secure stability. Any acceleration of this electron which is periodic will produce a periodic radiation of energy. Precisely such an acceleration is here present in the familiar rw^2 centrifugal acceleration which is periodic when we consider radiation along any one fixed direction. The frequency of this acceleration determines that of the radiation just mentioned. The electromagnetic effect is roughly that of an alternating displacement current.

2. Let us next suppose that instead of a single corpuscle we have a large number distributed throughout the same orbit. Their radiation is now almost nil, the vector sum of the accelerations being zero and the electromagnetic effect being roughly that of a *steady* current.

If the ring does not contain so many of these self-repellent corpuscles as to become unstable we have a simple type of a non-luminous and, during stability, non-radioactive element.

Imagine now that these electrons are the same for all elements; then one element differs from another mainly in the number, disposition and character of the rings which surround the central attracting charge, the number of corpuscles being 'of the same order as the atomic weight.'[4]

Such is a rough sketch of the normal Saturnian atom. The beautiful manner in which this structure permitted J. J. Thomson to infer the same periodicity in electrochemical properties as that contained in Mendelejeff's table is already familiar to you. But for the present inquiry this exquisite achievement of Thomson's is merely an 'aside.' So also is Drude's elegant connection of electrical and thermal conductivities in metals. Likewise his explanation of the Hall effect.

We come now to the question which is fundamental to all spectroscopic theory, namely, *under what conditions* does a gas atom become radiant.

This question may be asked and answered in two different senses:

First, one may inquire as to the laboratory conditions necessary to produce luminosity in a gas; the corresponding answer is threefold: either a high temperature, thus obtaining, in some rare cases, a heat spectrum, or secondly, a rapid chemical change as in flames, or thirdly, an electric field as in the arc, spark and vacuum discharge.

Again, one may ask what is the difference between the internal conditions of a radiant and non-radiant atom. So far as I am aware, this latter query has never received an answer which is definite or based upon indisputable experimental evidence. However, the Zeeman effect points to rotation in the luminous source and suggests the revolving electron as the light-giving body; but it is difficult to see how one electron could give rise to more than one line in the spectrum. Not only so, but, since the electrons are the same for all elements, it is clear that the electrons alone can not emit characteristic spectra, the

[3] Jeans, *Phil. Mag.*, **2**, 425, 1901.

[4] J. J. Thomson, *Phil. Mag.*, **11**, 774, 1906.

'sign-manual of the elements.' Riecke and Stark[5] have furnished us excellent experimental reasons, by observing the motion of luminous lithium vapor towards the cathode, for thinking that the radiant source is the positive ion; this, it will be noted, is not at all inconsistent with the evidence of the Zeeman effect, since the positive ion carries with it probably a large number of negative electrons, being itself merely a neutral atom minus one or more negatively charged corpuscles.

Thomson has recently presented three different lines of argument for thinking that the number of corpuscles in the atom is of the same order as its *usual* atomic weight, *i. e.*, in terms of hydrogen as unity. But most elements emit a number of spectral lines which is enormously greater than their respective atomic weights.

Thomson is, therefore, driven to conclude that "when an atom of an element is giving out its spectrum either in a flame or in an electric discharge, it is surrounded by a swarm of corpuscles; and combinations not permanent, indeed, but lasting sufficiently long for the emission of a large number of vibrations, might be expected to be formed. These systems would give out characteristic spectrum lines; but these lines would be due not to the vibrations of the corpuscles inside the atom, but of corpuscles vibrating in the field of force outside the atom."[6] The immediate cause of luminosity would be the bombardment of this system by free corpuscles, or in the case of flames the disturbing cause would presumably be molecular collapse.

At another time and place Thomson fortifies his view as to the complexity of the radiating atom, by citing the discovery of Lenard, that the speed with which the corpuscles are expelled from the atom by ultra-violet light does *not* depend upon the intensity of the incident ultra-violet light; thus indicating the necessity of at least two independent vibrating systems within the radiant atom.

I am not clear as to the proper interpretation of the measurements which have been made by Stark[7] upon the Doppler effect in hydrogen canal rays; but in any event they would seem to prove that the luminous source in the vacuum tube is not the simple corpuscle of the cathode rays, but the more complex, positive ion (not necessarily the positive charge) of the canal rays. While the experiments of Hull[8] during the past year combined with that of Schuster and Hemsalech point to a luminous source of such size and complexity that a condition of luminosity may be 'propagated along' it.

The upshot of the whole matter, then, is that we are landed with a picture of the radiant atom which is complex quite beyond description. One is reminded, indeed, of the words which Marie Corelli puts in the mouth of Lionel, the youthful hero of her 'Mighty Atom.' "Oh, dear Atom!" says he, "you must be very much more than I have been taught to believe you are."

Let us, however, accept the structure as we have received it and, with apologies for any feature of it which has not been correctly represented to you, let us now ask ourselves, how well it can serve as a foundation for our spectroscopic edifice.

APPLICATION OF CRITERIA

We may make this test most easily perhaps by asking how this atom will account for the nine fundamental phenomena mentioned above, and—

1. Does this Saturnian system give sharp lines? Can one predict from its structure that its radiation will be concentrated in a

[5] Riecke & Stark, *Physik. Zeitsch.*, **5**, 537, 1904.
[6] Thomson, *Phil. Mag.*, **11**, 774, 1906.
[7] Stark, *Ann. d. Physik.*, **21**, 401, 1906.
[8] Hull, *Proc. Roy. Soc.*, A, 521, p. 80, 1906.

few definite positions in the scale of wave lengths? I think it must be admitted frankly that, in the picture of the atom as given us, there is nothing which determines the rate of rotation of the corpuscle in its orbit, and nothing, therefore, which gives the same periodicity of radiation for all atoms of any one element.

This difficulty has been stated in a very forcible manner by Professor Jeans, and again by Lord Rayleigh. Each of them has proposed a method of getting around the difficulty, one[9] by introducing a law of electrical action different from the simple law of inverse squares, the other[10] by introducing mobile negative particles, which do not revolve, but which vibrate about their positions of equilibrium located in a rigid positive charge.

But the adoption of either of these suggestions would completely change the entire character of the atom. It may be that we shall later be driven into the corner and be compelled to accept some such mode of escape. But at present these devices impress one as highly artificial, and too inconsistent with other facts to warrant adoption.

The crux of the situation seems to be just here, if one assumes that the frequency of the radiation is identical with the rate of revolution of the corpuscles, he can not expect sharp lines in the spectrum. If, on the other hand, one assumes that light is due to the internal vibrations of the corpuscles, then not only does he fail to predict the Zeeman effect, but he is forced to conclude that since the corpuscles appear to be the same for all elements, the spectra of all elements should be identical. To derive the Zeeman effect from a rectilinear vibration by substituting for it two circular vibrations would seem to employ a purely kinematic device instead of offering a physical explanation. Nor is this all: The value of e/m obtained from the Zeeman effect is, if not correct, at least in beautiful accord with values determined in a variety of other ways.

Summarizing, one might say that the adoption of the Saturnian atom would compel us either to give up the Zeeman effect, or to give up sharp lines in the spectrum. On the other hand, I am not aware that it has ever been shown that even in a gas-spectrum the region between any two lines *is* entirely free from radiation. Is there any spectrograph so free from diffused light as to make an experimental answer to this question anything other than a more or less rough approximation? But even if every spectrum is, to some slight extent, continuous, the fact remains that spectral lines are essentially sharp.

2. Passing now to the second fundamental fact, which is that spectral lines are *not* perfectly sharp, but (within limits not yet resolved by any grating) possess a complicated structure, Professor Michelson[11] and Lord Rayleigh[12] have shown that in the case of a gas at low pressure the chief, if not the only, cause of widened lines is motion in the line of sight, an effect which depends as much upon pressure and temperature as upon atomic structure. But when it comes to the asymmetric distribution of intensity within these narrow lines, *i. e.*, a linear structure such as has been revealed to us especially by the interferometer in the hands of Michelson, an effect which would appear to be a function solely of atomic structure, then the chances of explanation in terms of the Saturnian atom appear even more remote than in the case of perfectly sharp lines.

3. The next query to be presented to the Saturnian atom is what explanation can be offered for the fact that very many lines in

[9] Jeans, *Phil. Mag.*, 11, 607, 1906.
[10] Rayleigh, *Phil. Mag.*, 11, 118, 1906.
[11] *Astroph. Jour.*, 2, 251, 1895.
[12] *Phil. Mag.*, April, 1889.

the spectra of the elements are arranged in series such that the wave lengths of any one series are functions of only two constants and the successive whole numbers?

So far as I am aware, no answer which is even approximately satisfactory has ever been offered in reply to this question. The fundamental difficulty here has been shown by Lord Rayleigh to lie in our measure of force, so to speak; in the fact that force is a second derivative of displacement with respect to time. Describe any dynamical system you please in terms of a differential equation; integrate it under conditions which yield a periodic solution; solve for the frequency, and you will find its value always entering to the second power.

But the difficulty under which the Cambridge atom here suffers is not peculiar to it alone.

Ritz,[13] in a doctor's dissertation of extraordinary merit, offered at Göttingen, has succeeded in devising a formula which contains fewer constants than that of Kayser and Runge, yet represents the observed wave lengths with a distinctly higher accuracy. And it might, at first glance, appear that we have here a truly dynamical explanation of the series phenomenon. But on closer inspection one finds that the fundamental picture—the mechanism, if you please—from which Ritz derives his differential equation is one having properties which are purely hypothetical and, in nature as we know it on a larger scale, quite impossible.

His vibrating body is a square (sometimes a plate, sometimes a membrane), whose behavior he studies under different boundary conditions. But it has this remarkable property that the effect of any one element of the membrane upon any other element is not merely a function of the distance separating the elements, but varies directly as this distance. A device so artificial could at most be called quasi-kinematical or purely mathematical. However, in each of the particular cases which he has integrated the frequency expression turns out to be practically identical with Rydberg's formula. The only dynamical justification for the entire proceeding appears to lie in the fact that he has chosen a two-dimensional body to yield a double infinite number of spectral lines.

Garbasso[14] has made an interesting attempt to obtain the Kayser and Runge series from certain combinations of Hertzian oscillators. And his solutions have this special merit, namely, they all refer to physically realizable models. But the number of frequencies which he has computed is too small to furnish even an approximate test as to whether they satisfy the law of Kayser and Runge, much less do they point out a general dynamical system from which the law of the series may be derived.

In spite of the fact that no satisfactory explanation has been obtained, one can hardly avoid the conclusion that Rydberg's formula is something more than a convenient expression for interpolation. The fact that his second constant, N_0, is the same for all elements, while another has a characteristic value for each particular element, and that a third constant locates the particular series in any one element, would seem to indicate that these three quantities are in some sense parameters of matter. Yet I am aware that this view is a mere suspicion and is not at present capable of proof.

When other types of spectra, such as that of iron, are brought under the 'reign of law' we may find a simpler view; or what is more likely, we may feel, with

[13] Ritz, *Ann. der Physik.*, **12**, 264–310, 1903.

[14] Garbasso, 'Theoretische Spectroskopie,' pp. 130 and 180, 1906.

Professor Runge, that 'nature is getting more and more disorderly every day.'

4. Passing now to the pressure shift, we owe to Dr. Humphreys, one of the discoverers of the phenomenon, a clear explanation in terms of the Saturnian atom.

He points out first of all that an atom built on the model indicated, with quantitative specifications such as these given, by experiment, will exert an enormously powerful field at points near its center. And since the convection currents here existing are practically equivalent to Amperian currents in circuits devoid of resistance, it is clear that any currents induced in these atoms by attempting to thrust through them more or fewer lines of force than they now contain will be permanent and, therefore, unlike the induced currents in the wire circuits of our laboratories.

But an increase of current in such an atom means an increase of speed in the corpuscles, and this in turn means presumably an increase of frequency. From this it follows that, if by any means two atoms are brought closer together there will in general be a change of frequency, and one may expect this change to be sometimes an increase and sometimes a decrease; that is to say, two atoms which are made to approach by pressure, and which we may imagine as strung on a common axis, will sometimes be rotating in the same sense and sometimes in the opposite sense. The increase and decrease of frequency thus secured by pressure will have the effect of widening the line. The plausibility of this argument is much enhanced by the enormous strength of the magnetic field in the neighborhood of one of the magnetic atoms; in the case of the iron atom amounting to as much as 150,000 C.G.S. units at a distance of ten radii from the center and, of course, a thousand times greater than this at the center. So much for the widening due to pressure.

But Dr. Humphreys has also very cleverly suggested that this widening will not be symmetrical about the original position of the line, but about a new position on the red side of the old. For when two atoms happen to be rotating in the *same* direction they will attract each other and then get 'into the stronger portion of each other's magnetic field.'[15] In other words, those effects which result in lengthening the waves will be much more marked than those which shorten the waves. Hence increase of pressure will be accompanied by shift towards the red. It would be exceedingly interesting to know what difference of structure exists between the radiant sources of lines and of bands which causes this explanation to break down when applied to the latter.

5. Passing now to the effect of a magnetic field, an experimental fact which largely established, although it did not suggest, Lorentz's conception of the electron vibrating about an attracting center, it is at once evident that the Zeeman phenomenon must follow as a deduction from the Saturnian atom.

But Preston and Runge and Paschen have shown that the normal triplet is by no means an ordinary occurrence; on the other hand the breaking up is very much more complicated, a single line yielding anywhere from 3 to 14 components.[16]

Beautiful as the general agreement beween fact and theory here is, one finds it peculiarly difficult to understand how the central line of the normal triplet—the one due to the component of motion along the lines of force—can be split up at all by the magnetic field. But since, as a matter of fact, this component *is* split up, it is

[15] Humphreys, *Astrop. Jour.*, **23**, 243, 1906.
[16] Runge & Paschen, *Abh. Ber. Akad.*, February 6, 1902.

only fair warning that the forces here involved are possibly not to be limited to those of purely electrical origin; but it is not obvious what experiment can be devised to answer these questions.

6. Passing next to that somewhat motley group of phenomena which we have classed under the head of Multiple Spectra, I am not certain that there is a single fact in the entire group that can be predicted from the structure of the atom which has been assumed.

In his Royal Institution lecture[17] of this year, J. J. Thomson has suggested an atom with certain capacities for receiving and spending energy, and has described this atom by simple differential equations, involving certain atomic constants; but the connection between these constants and the Saturnian atom are by no means clear.

So that while he accomplishes the explanation of the phenomena for which this new atom is introduced, the explanation can hardly be said to hinge upon the atomic structure, which has so highly recommended itself in other directions.

At present, we seem to be justified in going little farther than to say that *rapidity of change of electric field* seems to be *a* (not *the*) determining factor in nearly every case. The main difference between the arc and the spark appears to be confined to the earlier stages of the spark. The oscillograph shows that spark lines are introduced into the metallic arc when the break is quickened; the interruption of an intermittent arc is very much hastened by a hydrogen atmosphere; and one might think that, therefore, the action of hydrogen in introducing the spark lines is completely accounted for, and perhaps justly so, if it had not been discovered by Hale, Adams and Gale[18] that an arc fed by a small steady current and surrounded by hydrogen also yields spark lines. But this calls for an examination of the steady (?) current by means of the oscillograph.

The effect of a very minute current in introducing spark lines probably also rests upon the greater rapidity with which the small current is interrupted. The effect of self-induction is to retard the break, and hence obviously to obliterate spark lines. The effect of a parallel capacity is, of course, to increase the speed of break. The spark lines obtained in arc under water are apparently special cases of the effect of a hydrogen atmosphere and a consequent rapidity of break.

A most valuable research at the present time would be one which would determine whether for a 'quickness of break' as a unifying principle we should substitute 'rate at which energy is delivered' or, as Thomson suggests, 'rate at which energy is delivered *combined with rate at which energy is spent.*'

Until more definite information upon this point is obtained, it remains almost impossible to say how the Saturnian atom must be modified in order to explain multiple spectra.

7. As to the relation between spectral phenomena and atomic masses, we must, I think, all feel the most hearty admiration for the manner in which Professor J. J. Thomson has succeeded in picturing the periodic law as an almost immediate consequence of the atomic structure which he has proposed. The way in which the normal atom, by the addition of a few subatoms, becomes electro-positive or electro-negative is especially attractive. The achievements of Runge and Precht[19] in closely approximating if not accurately determining the atomic mass of radium is

[17] Thomson, *Chemical News*, **94**, 197, 1906.

[18] Hale, Adams and Gale, *Astroph. Jour.*, **24**, 213, 1906.

[19] Runge & Precht, *Physikal. Zeitschrift*, **4**, 285–287, 1903.

equally striking. Rydberg[20] has pointed out that certain spectroscopic properties of the elements recur with exactly the same periodicity as that discovered by Mendelejeff.

But it is important to observe that in none of these laws is the question of atomic structure involved, but only that of atomic mass. Not a single one of these phenomena has been predicted from previous notions concerning the atom, and indeed all our views concerning the Saturnian atom, with the single exception of the Zeeman phenomena, appear to be singularly devoid of that spirit of prophecy which characterizes all sound theory.

8. When confronted with the fact that many spectral lines show self-reversal, the atom which is now on the witness stand replies that its explanation of this phenomenon is identical with that of any other atom which consists of a vibrating mechanism.

The essential feature of a line-reversal appears to consist of a source *within* the arc or spark which emits, from whatsoever cause, a relatively wide line—thus approximating in small degree the incandescent solid first used by Kirchhoff. The *outside* region of the arc or spark emits, from whatsoever cause, a relatively narrow line, and its radiant atoms are, therefore, capable of absorbing only certain periods from those which appear in the broad or inner source.

Accordingly, the phenomenon of reversal is, in a certain very true sense, *not* an atomic problem. The fundamental question here involved is, however, the following, namely, how does it happen that, in the *inner* source, some atoms have their frequencies slightly increased while others have theirs slightly diminished? And this *is* an atomic problem.

[20] Rydberg, 'Rapports Congrès de Physique' (Paris), II., 217.

We may say that it is due to 'increased density' of the luminous vapor, but we are little wiser for that. In this emergency, the Cambridge atom with its entourage of stray corpuscles shows itself very capable; for it is exactly in such a region, as the interior of an arc, where the electric field is strong, and where collisions are frequent, that one might expect this 'swarm of corpuscles' to be varying largely—thus altering slightly the period of the radiant source, whatever that may be, both by change of inertia, and by change of electric field—acting, so to speak, both upon the numerator and denominator of the expression for the period. The case of double reversals has been reduced to that of single reversals by the clever experiments of Dr. Humphreys.[21]

The case of Wolf-Rayet stars[22] where H^{α} and H^{β} are bright while the remaining hydrogen lines are dark is, so far as I am aware, an unsolved puzzle.

9. Regarding the last of the nine criteria which have been cited, namely, the well-nigh impossible feat of securing a line-spectrum from a gas by means of heat alone, the situation seems to be as follows.

If one assumes that ordinary temperatures are due to the translational energy of the atom, while light consists in dissipation of vibrational energy *in* the atom, then Jeans[23] has proved, on dynamical grounds, that it is possible only in a minute degree to transfer energy 'from the principal degrees of freedom to the vibratory degrees of freedom'—at least with any temperatures which are encountered on this planet. In the case of ordinary collisions, the transfer is infinitesimal on account of the high frequency of the vibrations as compared with the duration of the collision; in the case of those rare collisions in which the

[21] Humphreys, *Astroph. Jour.*, **18**, 204, 1903.
[22] Campbell, *ibid.*, **2**, 177, 1895.
[23] Jeans, 'Dynamical Theory of Gases,' Ch. IX.

duration of collision is comparable with the period of vibration, the transfer of energy is 'infinitesimal on account of the extreme rarity of these collisions.'

This point of view has, I think, been supported by the experience of every one who has attempted to obtain characteristic spectra from gases under conditions in which electrical and chemical processes were excluded.

The assumptions back of Jeans's discussion are to be justified, if at all, by experiment. Hence the importance of such work as that which King,[24] Hale[25] and others have recently been doing by means of the electric oven, and of the fundamental experiments of Wood upon optical resonance.

As to the bearing of the Saturnian atom upon this fact, one finds it in about the same position as any other elastic atom, except that for ordinary mechanical rigidity one has to substitute the quasi-rigidity which comes from rotation of the electrons about the positively charged center.

The effort to render a gas radiant by means of high temperature alone has been aptly characterized by J. J. Thomson as an effort to boil a tea-kettle by burning down the kitchen; the spectroscopic analogue of Lamb's roast pig.

In view of all the evidence, the conclusion would appear to be that spectroscopists have greatly exaggerated the rôle of temperature in terrestrial sources. That the behavior of an arc or spark is determined largely by the temperature of its *electrodes* there can be no doubt; but it seems almost equally certain that the effect of changing temperature upon the character of the spectra is produced through the intermediation of changed electrical conditions in the source.

CONCLUSION

In turning the pages of Kayser's great compendium, which so adequately represents the present phase of spectroscopy, there is but one tinge of disappointment; and this is that, in the presence of such a wealth of facts, there is so little in the way of fundamental well-established unifying principles. And yet the only remedy appears to be one of the homeopathic sort, namely, more facts.

There is, however, this comfort: things are not as bad as they used to be. Our condition is somewhat that of the old judge who never liked to admit that he was not in perfect health. On one occasion, when he was just recovering from an illness, a friend met him on the street and asked him how he was feeling. "Well!" said the judge in reply, "I am not quite myself, but I am a great deal better than I was at the time when I was not so well as I am now." This, too, is to be remembered, that we can never hope for any solution which can in any sense be called final—*all* solutions are merely passing phases—the problem is not one either of mathematics or of history.

Let us then continue our search for the facts of the case confident in the belief that when this work has been properly accomplished, the unifying principle will be at hand. It should be to us a matter of no small pride that it is to our fellow members in this section that spectroscopy owes the bolometer, the curved-grating, the echelon, the spectroheliograph, and, therefore, in large measure the beautiful results obtained with these instruments.

In the meantime we must, I believe, all gladly admit two things: first, that the atom which we associate so closely with the Cavendish Laboratory more nearly supplies the desired principle than anything else which has been offered, and secondly, that the emission of a line spectrum is a very imperfectly comprehended phenomenon.

HENRY CREW

[24] King, *Astroph. Jour.*, **21**, 236, 1905.

[25] Hale, Adams and Gale, *ibid.*, **24**, 213, 1906.

SOME PROBLEMS CONNECTED WITH DEEP MINING IN THE LAKE SUPERIOR COPPER DISTRICT

THE copper mines of the Lake Superior district are essentially low grade. Their profitable operation is made possible by the great extent of the lodes, their comparative uniformity of character and the investment of great sums of money to maintain operations on a vast scale over a long period of years.

With but one important exception, the lodes are the vesicular tops of ancient lava flows which subsequent to solidification have had the cavities wholly or partly filled by the deposition of various minerals, among which is native copper. They dip at angles varying from 38° to 70°.

The modern shafts through which the rock is hoisted are either inclined, following the plane of the lode, or are vertical. The inclined shafts are of dimensions such as to provide for two railroads of approximately standard gauge on which run the 'skips' which are operated in balance. In addition there is room for the ladder way and air pipes, usually placed at one side. The vertical shafts have compartments providing usually for 'cages' and pipe and ladder way. Several of the inclined shafts are over 5,000 feet long. One has a length of 8,100 feet. Of the vertical shafts the three deepest are, respectively, about 5,200, 5,000 and 4,900 feet deep.

Long before such depths were actually reached there arose the question as to a possible limit set by the ultimate crushing strength of the rock which is penetrated. Manifestly, mining can not go to a depth such that the weight on walls of drifts and stopes will exceed the ultimate strength of the material of which they are composed. There is a widespread impression that the lake mines are approaching such a limit. There are current statements to the effect that pieces of rock occasionally snap off the rock faces because of the great strain, and are violently projected as if propelled by an explosive.

In this connection a few figures will be of interest. The average density of the rock of the copper-bearing series is not far from 2.87, that is, a cubic foot weighs about 179.3 pounds. Therefore, a horizontal square foot of area at 5,000 feet from the surface has above it a column of rock weighing 448 tons. The ultimate crushing strength of the average rock is not well known, but since it is mostly trap this may be safely assumed as at least 1,200 tons per square foot. If, therefore, the square foot above defined carries the entire column above it, it is loaded to much less than half the crushing strength and only at nearly three times the assumed depth will the load reach its crushing limit. At a dip of 38°, the pressure normal to the plane of the lode at 5,000 feet from surface is only 354 tons per square foot. It is in this direction that the crushing forces are mostly called into play. As the dip increases this normal pressure of course diminishes. At 52° it is 278 tons, and at 70° it is 152 tons per square foot.

However, the matter does not end here. The removal of large portions of the copper zone leaves considerable areas of the roof or hanging wall to be supported by the pillars which are left for the purpose, or by the walls of the opening, or by both. The weight on pillars and walls is thus increased and may easily approach the crushing limit. Take, for example, a long pillar 50 feet wide having on either side an open space of 150 feet. Suppose it in a lode dipping 38°. Allowing for neither rigidity nor arching, and supposing the weight on the pillar evenly distributed, at 5,000 feet deep it would be subjected to a pressure of 1,239 tons per square foot, a pressure under which it would fail.

As a matter of fact, in such a case the rigidity of the rock mass distributes a large part of the load out over the rock beyond the walls of the opening. That this rigidity may be considerable is illustrated in several cases where areas of hanging as wide as 200 feet or more have no support between walls, and yet have stood up for several years. They are not, however, at maximum depth.

In such an area a pillar when first cut out may have to carry but little more than its previous load. As the hanging wall slowly bends the pillar must take up more and more of the extra weight. This is not applied uniformly. As the rock between pillars and walls bends downward the tendency is to concentrate the load at the edge or face of the pillar, or wall, much as a beam does when supported in like manner. The outer parts of the pillar may thus become overloaded and here it will fail.

It does so by the splitting off of pieces of rock much as may sometimes be observed with a specimen in the testing machine, though on a much greater scale. These pieces break from the base as well as the top, and, as a rule, like any hard rock under a crushing load, the pillar fails suddenly. Small pieces of rock may fly to a considerable distance, and such occurrences have undoubtedly given rise to the above-mentioned exaggerated impression of the compressive stress to which the rock is subjected in the lowest levels.

The hanging rock mass moves, of course, when the pillar crushes, and the vibration due to the sudden though slight displacement is often conveyed to the surface. The result is a miniature but perfectly genuine earthquake which may be felt over a distance several times that of the pillar from the surface. With the crushing of the pillar and the movement of the hanging a readjustment of the weight takes place, and the process begins over again. Instead of the process being repeated exactly it is possible for the hanging to break in such a manner that the arching effect may protect this pillar, and place the load on others. Eventually, at great depths the hanging and foot must come together, and in one mine the final steps in the process came so rapidly as to completely wreck it.

The pressure normal to the plane of the lode is not the only action which may appear. The pillars are not, as a rule, separate from either foot or hanging. They are parts of the same rock mass, and it is not possible for the hanging to slide over the pillar. In consequence the readjustments which take place when a pillar fails as above described sometimes put an enormous longitudinal thrust on the foot, and in places its surface portion has buckled up under such stress. Also, at points where shaft pillars have been weak, shafts have been pinched and twisted under the same conditions so as to interfere with their operation.

Experience seems to have shown that at the great depths recently reached it is useless to expect to hold up the hanging rock mass for a long time by any scheme of pillars unless far too much of the lode is left in place, and that the only feasible method is to cut away the entire lode and permit the hanging to cave as rapidly as it will to the point where the broken rock fills again the whole space, and redistributes the weight over the footwall. Following this plan, cutting out the lode, or 'stoping,' begins at the point furthest from the shaft, and progresses toward it. With a wide shaft pillar, or with the shaft in the footwall, and with some such general method which avoids concentration of pressure where it can do harm, there seems no reason to anticipate serious difficulties due to crushing for a further depth at least as great as that already attained.

The difficulties of surveying the mine are not markedly increased by depth, except in the case of vertical shafts. When these are deep, and it becomes necessary to carry down an azimuth from the surface by means of two plumb lines hung in the shaft, there is presented a problem of considerable difficulty. It is almost impossible to free the lines entirely from disturbing influences which displace them from their normal positions. If either lines or plumb bobs are of magnetic material the presence of iron pipes in the shaft may result in seriously disturbing them. Falling water may be in such quantity and so directed as also to affect the position of the lines.

However, the air currents, which can not be wholly eliminated, whatever the precautions taken, are the most serious cause of disturbance. The temperature at the bottom of the shaft is higher than that at the top, and in consequence convection currents are formed. The heat supplied from the surrounding rock keeps them up. Indeed, with moderately steady temperature at the surface, and with the shaft idle, a remarkably stable condition of these air currents may come about. Elsewhere observations have been published by the writer,[1] showing that their effect on a plumb line may remain sensibly constant for hours at a time while deflecting the line from its vertical position. The stability of the currents is made possible by the large cross section of the vertical shafts, 10 feet by 22 feet to 10 feet by 30 feet outside of timbers, thus giving a large air body, and the constancy of the rock temperatures, and the supply of heat through the shaft walls. When we take account of the fact that a force equivalent to a horizontal pressure of 10 grains on a 60-pound plumb-bob suspended by a line 4,000 feet long will displace the bob one tenth of a foot from its normal position, it is easy to see how apparently slight causes may produce appreciable error in azimuth.

General attention was first attracted to this problem by the very noticeable divergence of two long plumb lines hung in shaft number five of the Tamarack mine. Of course, divergence alone would not affect azimuth, but the question confronting the surveyor is whether the divergence may not be due to some cause which may also displace one or both of the lines in a direction perpendicular to their plane. In the case mentioned it required a great deal of investigation and experiment to fasten the responsibility on the currents of air.

It is remarkable how many persons are ready to accept as an explanation of such divergence the statement that there is an excess of gravitation on each bob horizontally toward the end wall nearest to which it hangs. All are familiar with the picture in the text-books of the plumb line hanging near the face of a precipice being deflected from the vertical by the attraction of the mountain mass. The idea so strikingly conveyed by this picture while qualitatively correct seems in most minds to be quantitatively wrong. There is an excess of attraction on the bobs as stated, but its amount is far too insignificant to account for any observed divergence. At Tamarack number five it could account for no more than one one-thousandth of a foot. The convergence of vertical lines in that instance is over three times this amount.

The fact remains that the surveyor who must thus transfer an azimuth from the surface down a very deep shaft has a problem the proper handling of which must involve a careful study of the local conditions, particularly in regard to air circulation.

Increased depth tends to lessen the output of a given shaft, and in the effort to prevent this, and also to reduce hoisting

[1] See *Engineering and Mining Journal*, April 26, 1902, also *Electrical World*, April 26, 1902.

charges, loads have grown larger, likewise the speed at which they are hoisted. Loads of nearly seven tons are being raised on some of the inclines at speeds up to 40 miles per hour.

A considerable item in the hoisting charges is the cost of maintenance of the skip road, the expense per ton for this purpose increasing with the length of the shaft. The usual skip road is carried on heavy timbers which are placed transversely along the foot, and support large stringers to which the rails are spiked. The expense of maintenance of this road for great depths is such that some of the mines are substituting for it a road consisting of a rail attached to a concrete stringer which is borne directly on the rock of the footwall.

The stringer proper is about 13½ inches wide by 14 inches high. Beneath it and supporting it is a mass of concrete 16 inches to 18 inches wide extending to the rock. The depth of this supporting mass varies considerably, depending on the irregularities of the rock face to which it is attached. It ranges all the way from 4 inches to 2½ feet, and there is no reason why these limits might not occasionally be exceeded. The stringer and supporting mass are structurally one piece, being molded together. The stringer portion is reinforced by means of a 1⅛-inch steel cable passing longitudinally through its interior. The rail is attached by bolts which are spaced three feet apart, and hold it by means of clips which grasp the rail flange. The bolts pass through the stringer into a rectangular opening about three by four inches in section, which passes quite through the concrete, and affords access to the lower end of the bolt.

In building the road a form of plank is constructed having the cross section of the stringer, and a length of 15 feet. To its lower side are nailed the cores for the bolt openings just mentioned. The top is left open. From one to three of these forms are supported in place underground by suitable means, and to the sides are nailed boards extending downward to the rock. These make the form for the supporting part underneath the stringer proper. When all is firmly secured the rock face is thoroughly washed, and the concrete is filled in, beginning at the lower end. The mixture used is one part Portland cement, three of sand and five of crushed rock, and it is tightly rammed in place. As the filling proceeds the top of the form, or the cover, is completed by nailing on short pieces of plank. In the roads which have been built at a slope of 70° the structure is anchored to the footwall by heavy bolts spaced 8 feet apart. When the concrete has hardened sufficiently the form is removed and the rail is bolted in place. The road is then complete.

The first of these roads has been operating some three years, and has proved so satisfactory that the others have followed. Expectation regarding cost of maintenance has been fully realized, and, in addition, it has been found that the original cost of the road is less than that of wooden construction. Its disadvantages seem to be confined to the fact that, due to the unyielding nature of the support, the effect of a blow must be absorbed between wheels and rail, resulting in a perceptibly greater deterioration of both. However, this is far more than compensated by the decreased cost in other directions and the fireproof character of the road.

In the effort to counteract the increased costs due to great depth the economical generation, distribution and use of power have naturally received large attention. The long period of operation necessary makes it worth while to expend large amounts of money in installing machinery of large capacity and high economy. The

extreme in the direction of high-duty engines is represented at present in the Nordberg quadruple expansion, two-stage air compressor operating at the Champion mine. The engine is equipped with Nordberg's regenerative feed water heating system. It holds the world's record for minimum consumption of heat per foot-pound of work delivered, having shown a duty of 195,000,000 foot-pounds, being about 9 per cent. in advance of its nearest competitor.[2]

But one mine is so situated to be able to make use of water power. The Victoria, located near the Ontonagon River, has a considerable water power available which has been utilized in a novel manner. Distance from source to points of application is not great and the power for both mine and mill is distributed by compressed air. Moreover, the falling water operates directly on the air without the intervention of water-wheel or other machine.

Roughly speaking, this 'hydraulic air compressor' consists of a large underground chamber cut from the solid rock and having a length of 281.5 feet, a width of 18 feet and a depth of 26 feet. In normal operation the lower portion of the chamber is filled with water to a level of 14.5 feet from its roof. The remainder, having a capacity of over 80,000 cubic feet, is filled with air at 114 pounds gauge. The water outlet is through a tunnel 18 feet wide and 10 feet high, the bottom of the tunnel being a continuation of the horizontal floor of the chamber. This tunnel opens into an inclined shaft about 18 by 20 feet in cross-section, the discharge level of which is 271 feet above the water level in the chamber. The outlet for air is a 24-inch pipe leaving the chamber through the roof directly above the tunnel outlet.

[2] See description and report of test in paper on 'A High Duty Air Compressor,' by Professor O. P. Hood, *Transactions American Society of Mechanical Engineers*, 1906.

The inlet for both water and air is through three vertical shafts, each 5 feet in interior diameter, opening through the roof of the chamber at the end opposite to the outlets. Each shaft is tightly lined with concrete, and is continued down into the chamber by means of a somewhat flaring steel casing to a distance of about 15 inches below the water level. Just beneath, and reaching somewhat into the opening of the casing, is a conical boss of concrete. From water level in chamber through the air- and water-tight shaft to the water level at the intake above is 343 feet. This is 72 feet greater than the distance between the water levels at the outlet end, and this difference expresses the available head of water.

At the intake water is admitted through an annular funnel over a hollow ring from the flat inner periphery of which project 1,800 three eighth-inch tubes into the annular opening of the funnel. The water must flow over the mouths of these tubes, and in doing so it produces the aspirating effect which entrains the air in small bubbles. The air comes mainly through the tubes from the hollow ring which has suitable intake pipes extending above the water level. The mixed water and air fall through the vertical shaft, and are discharged radially from the annular outlet formed by the concrete boss and steel casing below. The current through the chamber is slow, and the air disengages itself, collecting in the top of the chamber, and displacing the water. By its pressure on the water surface in the chamber it maintains the 271 feet of difference in level between that surface and the one at the discharge of the outlet shaft.

While running at less than full capacity the water level in the chamber is prevented from being depressed further than 14.5 feet from the roof by means of a blowoff pipe, 12 inches in diameter, which opens

somewhat below the normal water level. When the water has been pushed down sufficiently air enters this pipe, and its escape relieves the excess of pressure. When the blowoff is in operation the appearance at its mouth greatly resembles the eruption of a powerful geyser. The stream of spray, due to the entrance of water with the air from the chamber, is thrown sometimes to a height of 400 feet.

The capacity when all intake shafts are operating is about 5,000 horse power. So far but one intake is used. This under test at near its maximum capacity showed an efficiency of better than 82 per cent. while delivering 11,930 cubic feet of air per minute at 128 pounds absolute pressure.

All machinery at the stamp mill and at the mine, whether on the surface or underground, is operated by compressed air. Beside utilizing cheap power the compressor has obvious advantages over the usual machine in the absence of parts to get out of order and in low cost of attendance.[3]

The foregoing examples are presented to Section D as illustrating the tŷpe of problems which are arising in connection with the extensive operations at great depths on the low-grade lodes of the Lake Superior copper district.

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Michigan College of Mines,
December, 1906

WHY HAS THE DOCTRINE OF LAISSEZ FAIRE BEEN ABANDONED?[1]

Perhaps the most remarkable change which economic opinion has undergone during the last fifty years has been the change from the extreme *laissez faire* doctrines of the classical economists to the modern doctrines of governmental regulation and social control. And yet there has been very little attempt to explain why *laissez faire* has been so generally abandoned. Its abandonment has been gradual and almost unconscious, not so much the result of any rival abstract doctrine, as the cumulative effect of experience, which in hundreds of individual cases has brought men face to face with the practical limitations of the let-alone policy. The movement is fast bringing us back to the old view by virtue of which economics was first named *political* economy.

The revival of governmental activity in economic affairs is due to causes which are partly political and partly economic. This paper has to do chiefly with the economic causes and we shall, therefore, merely note in passing the chief political aspects of the problem. One reason for the extension of governmental control of industry is the growing strength of governmental control in general and of popular confidence in it. *Laissez faire* was a natural doctrine in a time when governments were weak and inefficient. Change of power has brought change of the theory of power. Compulsory workmen's insurance we find in the strongly developed German Empire; railway rate regulation follows increased power and centralization of government. It may even be said that much of the modern government regulation of industry resulted from the attempt of governments to extend its powers in self-defense. It has been felt, for instance, that if the government did not control the railroads, the railroads would control the government. Government regulation here has taken on the aspect of a struggle for supremacy. Just as England feels the

[3] See description by A. L. Carnahan in the *Mining World* of August 25, 1906, and by C. H. Taylor in *Mining and Scientific Press*, August 18, 1906.

[1] Address of the vice-president before Section I.—Social and Economic Science—at the New York meeting of the American Association for the Advancement of Science.

necessity of having a navy equal to the combined navies of several other European powers, so governments feel that they must overtop the corporate aggregations of wealth with which they may have to cope.

Were there space we might discuss the question how far the movement toward governmental interference can profitably be pushed. The doctrine of socialism lies at the extreme opposite pole from the doctrine of *laissez faire,* and we are moving toward socialism dangerously fast. Yet there are insuperable obstacles to the success of socialistic projects. Governmental power and efficiency are limited and, when one class of society attempts actually to rule another, there is always a tendency to corruption, inefficiency, lack of adaptability to new conditions and abuse of power. Socialism can not be put in practise without opposition, and to maintain itself socialism must hold the opposing class in subjection. Nominally this subjection would be a benevolent paternalism, but in political history it is the universal experience that the party in power, to entrench itself against attacks, soon usurps more power, employs indefensible and oppressive methods and tries to establish itself in the enjoyment of special selfish privileges.

Our present purpose, however, is to study, not the political, but the economic, side of the problem. The doctrine of *laissez faire* is that governmental interference, in economic matters at least, is unnecessary and harmful. Sometimes it is added as a corollary that not only should government let individuals alone, but also that individuals should let each other alone. 'Live and let live' and 'Each for himself' are the mottoes of this type of individualism. The advocates of extreme *laissez faire* maintain that one class is not justified in imposing its tastes upon another. They say, we must not meddle with our neighbors' affairs, even if they are wasting their lives in what appears to us trivial, useless or positively harmful gratifications. Those who love art, science or literature have no right, we are told, to criticize those who are bored by these things, but love prize-fighting, fast horses, fast society or high living.

The reasoning by which these individualistic doctrines were supported may be briefly stated in two propositions: first, each individual is the best judge of what subserves his own interest, and the motive of self-interest leads him to secure the maximum of well-being for himself; and, secondly, since society is merely the sum of individuals, the effort of each to secure the maximum of well-being for himself has as its necessary effect to secure thereby also the maximum of well-being for society as a whole.

In the light of the experience of the last fifty years, it is not difficult to see wherein each of these two propositions is in error. First, it is not true that each man can be trusted to pursue his own best interests. Some men need enlightenment, owing to ignorance of what constitutes their best interests, and others need restraint, owing to lack of self-control in following them. The necessity for both enlightenment and restraint has always been recognized in the case of children, and an examination of actual conditions will show that they apply—often with equal force—to adults.

Liberty is certainly indispensable in a healthy society, but liberty insensibly verges upon license. While most of us would still agree that sumptuary laws are ill-advised, there is certainly good ground for maintaining that the liquor traffic should be put under some restraint, even if only by high license. It is not true that the drunkard is the best judge of what is for his own well-being and that of his family, and it is still less true that even when he thoroughly recognizes his failings he

will have the self-control to act upon that knowledge. Hence the liquor problem becomes a social as well as an individual question. Again it is not true that ignorant parents are justified in imposing their ideas of education upon their children; hence the problem of child-labor, instead of concerning only the individual, as was at one time thought, has important and far-reaching relations to society as a whole. The same principles apply to the restraint of gambling, vice, the suppression of indecent literature, the compulsion upon landlords to make tenements sanitary, and many other forms of governmental regulation.

Even where governmental intervention is impracticable or inadvisable, there will still be good reason for attempting betterment of conditions through the influence of one class upon another; hence come social agitations and the efforts of one class to educate or instruct another. On this principle are based the great modern movements for human betterment as exemplified by the Society for the Study and Prevention of Tuberculosis, the Society for Sanitary and Moral Prophylaxis, the National Civic Federation, the American Institute of Social Service, the National Child Labor Committee, temperance societies, college settlements, district nurse associations and other organizations.

Strange as it may seem to those of us interested in these movements to-day, the fact is that a generation ago many of them would have been regarded by the dominant Manchester School not only as impracticable, but as unnecessary and possibly harmful. The adherents of this school seemed to treat the difference between knowledge and ignorance as a mere difference in opinion, with which the government has no more concern than with difference of religious creeds. It is certainly true that the attempts of governments to impose what is regarded by the ruling class as the 'true religion' upon the entire people have always proved ill-advised; the recognition of this has produced the modern sentiment of religious toleration. But we are carrying toleration too far when we refuse to correct errors which science demonstrates to be false. There are doubtless millions of persons to-day who jeer at the idea that indiscriminate spitting is dangerous to public health, but it would be silly to allow their ignorant prejudice to prevail. The bacteriologist knows what the ignorant do not know, and every effort should be made to pass down this knowledge to the masses as soon as possible after it is discovered. We can not let any dogma of *laissez faire* prevent us from checking suicidal ignorance.

The world consists of two classes—the educated and the ignorant—and it is essential for progress that the former should be allowed to dominate the latter. But once we admit that it is proper for the instructed classes to give tuition to the uninstructed, we begin to see an almost boundless vista for possible human betterment. Instead of regarding the present state of society as a normal and desirable one because each man naturally 'seeks his own best interests,' we permit ourselves to judge each actual case by our own ideal standard. This standard may differ widely from the average of actual usage. We must always distinguish between the ideal or *normal,* and the real or *average.*

The average represents merely conditions as they are; the normal represents conditions as they ought to be. Yet nothing is more common than confusing the two. In fact, in most anthropometric or physiologic tables, the word 'normal' is used almost synonymously with 'average.' The normal height of man, his normal weight, his normal length of life, his normal diet,

strength, etc., are all identified with the average.

In this way all question of possible improvement is begged. We are stopped at the outset from asking, for instance, whether men in general are too stout, for the average weight of mankind is *assumed* as 'normal.' The absurdity of such procedure becomes apparent as soon as we consider cases in which, by common consent, the average and the normal are held to be distinct. For instance, the average adult man certainly does not have normal teeth, for they are usually half decayed; nor normal hair, for he is usually half bald; nor normal posture, for he is usually round-shouldered. Average health is below normal health, average morality below normal morality. In the absence of evidence we have no right to assume that the average and the normal are identical, even when we lack the data on which to base an opinion. It is only recently, and in consequence of the movement against tuberculosis, that experts have come to realize how widely different is the average air we breathe from air which is normal for human respiration, and that investigation has shown the average diet, in America at least, to be abnormally nitrogenous. In view of such revelations we should be open-minded enough to accept evidence—should it be offered—that the average span of life is less than half the normal span, and the average efficiency less than half the normal efficiency.

Those who habitually confuse the normal and the average are prevented from seeing the possibility of progress. They take the position, as unscientific as it is obstructive of progress, that 'whatever is is right,' presumptively at least, and brand every one who deviates from the average as an eccentric or a crank. The confusion between the normal and the average thus leads to the confusion between the eccentric and the pioneer. An eccentric or a crank is properly a person who deviates from the *normal,* and is almost the opposite of the pioneer, who deviates from the *average,* but toward the normal.

Discrepancies between the average and the normal may apply—in fact, do apply—to the economic side as well as to other sides of life. But this the *laissez faire* doctrine denied. The world as it is was thought to be nearly, if not absolutely, the best world possible. One example of this complaisant assumption was in the use of the term 'utility' to signify the intensity of desire that men have for things. So far as I know, the only writer who has attempted systematically to distinguish between the desires of men as they are and as they should be, is Pareto, who for this purpose suggested a new term—ophelimity—to replace 'utility' as applied to man's actual desires, reserving for the term 'utility' its original sense of what is intrinsically desirable. Thus, to an opium fiend opium has a high degree of ophelimity, but no utility. Economists have not yet laid sufficient emphasis on the distinction between true utility and what Pareto calls ophelimity. A whole range of problems of social betterment is opened up through the distinction. Economists have received with derision the suggestions of reform of Ruskin. But, however impracticable his specific proposals, his point of view is certainly saner than that of most economists; for, as Ruskin has pointed out, it is absurd to regard as equivalent a million dollars of capital invested in opium culture, and a million dollars invested in schools.

But there remains to be considered a second fallacy in *laissez faire.* Not only is it false that men, when let alone, will always follow their best interests, but it is false that when they do, they will always thereby best serve society. To Adam

Smith it seemed self-evident that a man served society best who served himself best—though he would certainly have admitted that the rule had exceptions in the case of thieves, assassins and others who are obviously enemies of society. But the extent to which the classical 'economic harmonies' were pushed by some writers, while not including such persons as thieves among beneficent workers, was, nevertheless, astonishing. Herbert Spencer's advocacy of freedom of private coinage is well known, though any one familiar with 'Gresham's law' knows how chimerical such an institution would be. A still more astonishing suggestion is that which Molinari is reputed to have made at one time, namely, that even the police function of government should be left to private hands, that police corps should be simply voluntary vigilance committees, somewhat like the old-fashioned fire companies, and that rivalry between these companies would secure better service than that now obtained through government police!

If we stop to classify the social effects of individual actions, we shall find that they fall into three groups: (1) those actions which benefit the individual himself and have no effect upon others; (2) those actions which benefit the individual and at the same time benefit society; (3) those actions which benefit the individual while at the same time they injure society. It is the third group which the *laissez faire* doctrinaires have overlooked, and especially that part of the third group in which the injury to society outweighs the benefit to the individual. As Huxley said:[2]

> Suppose, however, for the sake of argument, that we accept the proposition that the functions of the state may be properly summed up in the one great negative commandment—'Thou shalt not allow any man to interfere with the liberty of any other man'—I am unable to see that the logical consequence is any such restriction of the power of government, as its supporters imply. If my next-door neighbor chooses to have his drains in such a state as to create a poisonous atmosphere, which I breathe at the risk of typhoid and diphtheria, he restricts my just freedom to live just as much as if he went about with a pistol threatening my life; if he is to be allowed to let his children go unvaccinated, he might as well be allowed to leave strychnine lozenges about in the way of mine; and if he brings them up untaught and untrained to earn their living, he is doing his best to restrict my freedom, by increasing the burden of taxation for the support of gaols and workhouses, which I have to pay.
>
> The higher the state of civilization, the more completely do the actions of one member of the social body influence all the rest, and the less possible is it for any one man to do a wrong thing without interfering, more or less, with the freedom of all his fellow citizens.

In the examples given by Huxley, the acts complained of are injurious not only to society, but to the individual. But even when the act of an individual is actually for his own benefit, it may not be for the benefit of society. The paradox that the intelligent actions of a million individuals, each attempting to better his condition, may result in making the aggregate condition of the million worse, is illustrated by considering the effect of individual action in the case of a burning building. When a theater is on fire, thousands of frantic individuals are struggling to get out. In the panic, it is doubtless to the best interest of any particular individual to struggle to get ahead of the others; if he does not, he is far more apt to be burned. And yet nothing is more certain than that the very intensity of such efforts in the aggregate defeat their own ends. The reason is that the effect of the effort is chiefly relative; so far as one pushes himself forward he pushes others backward.

Numerous examples exist of actions which benefit the individual but injure so-

[2] 'Life and Letters of Thomas H. Huxley,' by Leonard Huxley, Vol. I., pp. 384–5, Appleton, New York, 1900.

ciety, or benefit a part of society but injure society as a whole. Thus, the city of Chicago, in tapping the Great Lakes for its new sewerage system, has tended to influence the level of those lakes and thereby affect economically a large territory, including several states of the Union and also Canada. It has been estimated that the level of the lakes may be affected as much as six inches.

One reason for federal interference in irrigation is that the water supply is often controlled by citizens of one state, while the land belongs to another state or to the United States, and cooperation between the two is difficult to secure. Water, in the arid lands of the west, is a prime requisite, and without it the lands have no value. From one point, Mt. Union, in the Yellowstone Park, three rivers begin—the Missouri, the Columbia and the Colorado—flowing into the Gulf of Mexico, the Pacific and the Gulf of California, and through a large number of states and a vast extent of territory. The mutual interests of the riparian owners and those affected by irrigation could scarcely be adjusted merely through the play of individual interests.

Similarly, the act of one individual in destroying forests influences climate and water supply and thereby affects other individuals in distant parts. Where individuals in the community are allowed to seek their own interests the destruction of forests in some regions inevitably follows.

A like effect was seen a few years ago in the case of the seal dispute between the United States and Great Britain. The play of individual motive in this case tended to the actual extinction of seals, and could only be curbed by the mutual agreement of nations to prevent pelagic sealing.

Individual action can not be trusted to provide fire-proof or slow-burning construction as required in a crowded city; for the individual, although interested in protecting himself from his neighbors' fires, is not interested in protecting his neighbors from his own fires; hence the necessity and justification for city fire ordinances. Similarly, soft coal, in such cities as Denver, St. Louis and Pittsburg, constitutes a veritable nuisance to the entire city; and yet the individual factory owner is undoubtedly following his own best interest in not substituting hard coal or using expensive smoke-consumers. Such protective measures would redound greatly to the benefit of the community, but only slightly to his own benefit; hence the necessity and justification for smoke ordinances. Individual action would never give rise to a system of city parks, or even to any useful system of streets. And where parks exist, as in the case of Battery Park, New York, there is a constant tendency for those seeking their individual interests to encroach upon them. In Hartford and other cities certain parks have in this way gradually disappeared, much to the damage of the public.

In the cases mentioned, of a conflict between social and individual interests, legal restraints become necessary. But there are many examples in which, for one reason or another, legal restraints are impracticable. This is particularly true in cases where a number of nations are concerned. There can be no question, for instance, that the standing armies and great navies are an almost intolerable burden in Europe, and that their existence has tended to increase the cost of our own army and navy, three thousand miles away. Nevertheless, in the absence of any central international authority or mutual agreement to bring about disarmament, it must be confessed that it is to the interest of Germany or France each individually to keep up its military equipment to a level comparable to that of its neighbors. Yet the aggregate effect of international competition for military power is to cancel itself out; the ad-

vantages and disadvantages are purely relative. The nations are in a mad race each to excel the other. Their object being purely one of relative advantage, such advantage can be shifted from one to the other, but can not accrue to all. A general increase in relative advantage is a contradiction in terms, so that in the end the racers as a whole have only their labor for their pains.

An economic example of the same international character, and one which has received very scant attention, is found in the increase of the monetary metals. The production and distribution of gold and silver is the effect of individual action, each person seeking his own best interests. Yet the aggregate effect upon these individuals may be injurious. The injury referred to is not the imaginary injury of an 'unfavorable balance of trade' which was the bugbear of the mercantilists, but the exact opposite. A nation which increases its stock of money is always and necessarily a loser. This increase costs the nation either labor of mining or commodities sent out of the country, and for this cost there is no return whatever. To assume that the increase of money is itself a valuable return is to commit the fallacy of inflationism. Money is a very peculiar commodity. A general increase of other commodities is an advantage to society, but a general increase of money is not. The inflationist reasons that if a government can enrich one person by printing paper money and bestowing it upon him, it has only to do the same for everybody in order to enrich the nation. The paper-money delusion is too well understood to require comment. It is, however, not always perceived that precisely the same reasoning applies to all inflation, even the inflation which nature herself creates when she unlocks her hoards of buried treasure. The United States now has $33 of money per capita as against $22 a few years ago, but we are no better off on that account. The smaller amount of money is as useful in exchange as the larger amount. There are, of course, transition evils in contracting or expanding the currency, but so long as the price level remains constant or certain, the absolute number of dollars of the circulating medium is a matter of indifference. It follows that any effort expended in increasing the stock of money is wasted effort, an effort without a return. This waste is a necessary concomitant of monetary individualism.

A not dissimilar case, and one which is now causing much discussion, is that of railroad rates. Those who have examined the working of competition in railroad transportation recognize the fact that this competition is of the variety called 'cut-throat' competition, and that no stable or normal rates for transportation, under which capitalists will consent to invest in railway-building, can occur through such competition. Those who advocate competition as a cure for the evils of railroad rates do not appreciate the mechanics of the problem. The effect of competition is to bring rates down to the cost of operation; it leaves no provision for interest on capital sunk in the enterprise. If the cost of operation is one cent per ton-mile, whereas two cents are required to include enough revenue to pay interest on original cost, rates under competition will inevitably sink below the two-cent level to the one-cent level. For if we assume that the two-cent rate is for a moment the ruling rate, it is clear that it would pay any individual competitor to cut under that rate in order to divert traffic away from his rivals. But as soon as he cuts below it, all the others must do likewise or lose their traffic. This competition is merely self-defense, and yet its ultimate effect is to injure, not benefit, all of the roads who engage in it. It is

cut-throat competition. In order that rates may be maintained at the two-cent instead of the one-cent level, either competition must be absent, or it must be partial or imperfect. In the actual railroad world competition is usually present at some points and absent at others. The consequence of this mixture of competition and monopoly is that rates will be determined differently for some points than for others, and this constitutes what is called local discrimination. In a régime where monopoly is present, discrimination, not only of this local character, but discrimination as to persons and as to commodities carried, is a natural and inevitable result. It is not, of course, a desirable result; but it is no more undesirable than is the cut-throat competition which is the other horn of the dilemma. This cut-throat competition discourages the investment of capital in new railroads, and the shippers and consumers must in the end suffer. This dilemma between the evils of monopoly and of competition leads to governmental regulation, though the efficacy of this remedy is not all that could be desired. It is not our purpose to discuss the best solution of so difficult a question. We are merely concerned in pointing out that this railroad-rate problem is partly due to cut-throat competition and that cut-throat competition is one more example of the suicidal effects of blindly following individual self-interest.

Numerous other examples might be given; we shall, however, content ourselves with one. As John Rae has pointed out, there exists a species of subtle competition in private expenditure, due to social rivalry —the desire for distinction through wealth. It has frequently been remarked among ladies' social clubs which begin with simple entertainments, that each successive hostess attempts, almost unconsciously, to surpass her predecessor in the entertainment offered. Beginning with tea and cake, the club ends with elaborate and expensive collations, until it produces a heavy drain upon the resources of its members. In precisely the same way, on a larger scale, there is laid a heavy burden upon us all through the social rivalry of individuals. If we study the history of Newport or similar fashionable resorts, we find that social racing has gradually resulted in setting a pace which only the most wealthy can keep up, and that even for them expenditure represents cost rather than satisfaction. This cost often takes the form of producing fictitious values on articles merely because they are 'exclusive.' As John Rae says:[3]

> A dish of nightingale's brains could scarcely be a very delicious morsel, yet Adam Smith quotes from Pliny the price paid for a single nightingale as about £66. According to Suetonius, no meal cost Vitellius less than £2,000 * * * Thus Adam Smith reckons the cost of some cushions of a particular sort used to lean on at table, at £30,000.

Nor do we need to draw our examples from ancient Rome. The 'History of Luxury' by Baudrillart will show the tendency to produce luxury out of social rivalry in all ages. It was only recently that an American in London gave a dinner party which was said to have cost $8,000. The table was placed in a large Venetian gondola set in the midst of an artificial lake, while in a smaller gondola near by a band was stationed.

Much has been said of late about the importance of living the simple life, but so far as I know there has been no analysis to show why it is not lived. This analysis would reveal that the failure to live it is due to a kind of unconscious cut-throat competition in fashionable society. When San Francisco was destroyed by earthquake and fire, much comment was made upon the fact that many did not feel their losses as

[3] 'Sociological Theory of Capital,' by John Rae, ed. by C. W. Mixter, MacMillan, 1905, p. 247.

much as might have been anticipated. One reason for this result is doubtless found in the fact that the losses were not relative. Had a single individual found himself suddenly reduced from a palace to a tent, his sense of loss and discomfiture would have been great. He could no longer return social entertainment among his former associates; he would feel 'out of it' and envy would gnaw at his breast. But after the San Francisco catastrophe there was little place for envy; all were in the same boat. There was no relative loss, there was only the absolute loss of creature comforts, and strange as it may seem to one who has not considered it, the absolute loss is the smaller of the two.

It is hard to overestimate the tax which is laid upon society through social racing. We are not conscious of this weight, because, like the weight of the atmosphere, it is always pressing upon us. The New York business man buys a silk hat as a matter of course. He does not think of its cost as a tax laid on him by society. He is satisfied because the hat fills a want, and he does not consider how that want originated. It is only when the tax varies by change of place, just as when atmospheric pressure varies by ascending a mountain, that he is at all aware of its existence. If he removes to a smaller town where social racing is less intense and the leaders in the race are unable to set so high a pace, he finds the tall hat no longer *de rigueur*. He drops off this and numerous other expenses and feels himself that much better off. A gentleman recently refused a salary of $7,000 in New York, preferring $4,000 in a smaller town, feeling that he could buy no more real satisfaction with the former than with the latter. The extra $3,000 meant simply that it would cost more to keep up with his neighbors.

The burden of social racing is laid not only on the rich but upon all classes. A milliner in New Haven recently thought to avoid competing with existing fashionable millinery establishments by catering to the trade of shop girls. To his surprise, he found that the tyranny of fashion was quite as strong among them. He attempted to put on sale a large number of $5 and $6 hats, but found great difficulty in disposing of them, whereas the few $15 and $16 hats met with a very ready sale. The shop girls wanted these hats to 'be in the swim.' Recently in France a whole family committed suicide because they had lost the capital which they considered necessary to keep their social position.

Many ingenious arguments have been made to justify luxury and in some of them there may lie truth. The fact that luxurious expenditure can be so readily cut down in hard times provides a sort of buffer against want and famine. The relations of luxury to the growth of population deserve careful study. But whatever the indirect benefits of luxury, certain it is that it forms a tax upon society, and a heavy one. It seems also true that where luxury is greatest civilization decays.

Were there more space we might discuss remedies for this social racing; but we must content ourselves with merely describing the phenomenon. It exemplifies the manner in which the self-seeking of each may create a burden for all.

From this and the other examples which have been reviewed we see that the mechanics of individualism is not so simple as the individualists have assumed. The old individualism requires two corrections: first, the individual may often be interfered with in his own interest, because either of his ignorance or his lack of self-control; secondly, even when an individual can be trusted to follow his own best interests, it can not be assumed that he will thereby best serve the interests of

society. A recognition of these two facts is essential not only to clear thinking, but as preliminary to any practical solution of the great problems of human betterment. We are doubtless to-day in danger of too much socialistic experimentation; but nothing can be gained and much may be lost by ignoring or condoning the opposite evils of individualism. In fact, the menace of socialism can best be met if we understand and acknowledge the evils which it is intended to remedy. The preliminary to remedy is diagnosis, and an accurate diagnosis will save us from the error of both extremes—the extreme, on the one hand, of an overdose of socialism, and the extreme, on the other hand, of omitting all medication whatever.

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SCIENTIFIC BOOKS

Sociology and Social Progress: A Handbook for Students of Sociology. Compiled by THOMAS NIXON CARVER, Ph.D., LL.D., David A. Wells Professor of Political Economy in Harvard University. Boston, Ginn and Company [1906]. Pp. vi + 810; 8°. List price, $2.75; mailing price, $2.95.

This is a timely and valuable book. In these days when social questions are attracting the attention of all, even the scientific specialists, and when an undigested mass of contemporary literature is being poured forth upon the public wholly incapable of appraising it, it is of the greatest importance that the utterances of the masters of thought, science and literature bearing on the subject should be made accessible to all as guides to public judgment. To do this is the purpose of this volume, and even a partial enumeration of the authors and works that have been drawn upon is sufficient to indicate the value of the compilation. The most important are: Comte's 'Positive Philosophy' (Harriet Martineau's English condensation), Buckle's 'History of Civilization,' Darwin's 'Descent of Man,' Adam Smith's 'Theory of Moral Sentiments,' Bagehot's 'Physics and Politics,' Fiske's 'Outlines of Cosmic Philosophy,' Herbert Spencer's 'Data of Ethics,' Kidd's 'Social Evolution,' Tarde's 'Imitation,' Galton's 'Hereditary Genius,' Machiavelli's 'Prince,' Aristotle's 'Politics.'

When we remember that about two thirds of the space is devoted to these works and a fair share to others ranking second only to these, we can well pardon the introduction of a number of lesser works and even some quite insignificant ones.

The selections from large works, which is no easy task, are judiciously made. For example, the three most important subjects treated by Buckle, viz., the influence of physical laws on society, the rôle of intellectual development, and the influence of religion, literature and government, are introduced here without abridgment. Darwin's chapters on sexual selection in relation to man are given in full with the exception of the scientific details, so that it is quite readable. And so of the rest. Those who read these works in their youth and retain only a vague impression of them, have an opportunity here to refresh their minds with the cream of them, and those who never read them at all can gain from this digest a fairly adequate idea of them.

But Dr. Carver has intended that the book, as its title implies, should be something more than a mere compilation. In the first place, he has supplied an introduction to it of his own, in which he sets forth as clearly as has ever been done the true scope and method of sociology. His treatment is thoroughly sane. He is an economist of the modern school which has arisen from the recent revised definition of value, and which brings the great sciences of economics and sociology into sympathetic touch with each other. If he lays somewhat undue stress on social progress, he only does what others, including the present reviewer, have done before they had devoted themselves to a serious study of the conditions of social order. The doctrine which he specially emphasizes as his own, and which he had earlier set forth, is expressed in these words:

Every great historical epoch and every variety of social organization must be explained on the basis of factors and forces now at work, and which the student may study at first hand.

This is now called sociological uniformitarianism. It was strongly hinted at by Sir Charles Lyell himself ('Principles of Geology,' eleventh edition, Vol. I., p. 167). It is called by Gumplowicz 'the eternal uniformity (*Wesensgleichheit*) of social processes' ('Rassenkampf,' p. 172), and is discussed at length by him. It has been insisted upon by Bernès and Regnano in Europe and by Ross and Small in America, and was applied by Schleicher to language.

Conformably to this philosophical introduction, Dr. Carver has undertaken to classify his materials under certain logical heads. The late Dr. G. Brown Goode described a museum as 'a collection of labels illustrated by specimens.' The materials of this work have about the same importance relatively to these heads as do the specimens of a museum to the labels. He divides the matter of the book into three parts, the first relating to the nature, scope and method of sociology, the second to its bearing on social progress, while the third part embraces the various factors of social progress, which he still further subdivides into physical and biological, psychical, social and economic, and political and legal.

This classification may have value for some minds, but doubtless chiefly for that of the compiler, and the ordinary reader will not generally know, and will care less, where he is in the scheme when he is reading any of the interesting essays that the work contains. It would have been just as well to arrange them in the alphabetical order of the authors, or still better in the chronological order of the works.

As already said, the authors cited are nearly all either famous or of a high order, and some of the essays whose authors are either contemporary or somewhat less well known are among the best selections. The essay entitled 'War and Economics in History and Theory,' by Edward Van Dyke Robinson, certainly answers this description. There are, however, a few of the articles whose appearance in this roll of honor is matter for regret. Only one such need be mentioned, viz., Drummond's Struggle for the Life of Others, from his book 'The Ascent of Man,' 1894, the very title of which was plagiarized from the address of Dr. Frank Baker, as president of the Anthropological Section of the American Association for the Advancement of Science at the Indianapolis meeting, in August, 1890, published in the *Proceedings,* Vol. XXXIX., p. 351, and also in the *American Anthropologist* for October, 1890, Vol. III., No. 4, p. 297, and with which Drummond must have been familiar. But this might have been pardoned if the book itself, or most of what is true in it, were not a plagiarism from Haeckel and other authors. Even this offense, however, is less grave than the utterly unscientific and mainly false attitude of the author in the application and interpretation of his facts.

From the standpoint of book-making this volume has its defects. Not to mention its ugly, unesthetic style of binding, it is one of those books in which the user is always lost and constantly compelled to revert to the contents to find what he wants. This could easily have been remedied by head-lines showing 'who is talking' on any page. But such things are 'trifles light as air' by the side of the sterling merits of the work.

Lester F. Ward

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Variations of the Bones of the Face[1]

This work (which should have been reviewed sooner) is the continuation of Professor Le Double's great undertaking which is to give us a complete account of the variations of the human skeleton. His last work, which was noticed in these pages, treated of the variations of the cranial bones. This one, therefore completes the head. In the preface the author gives some account of his labors and maintains that none of his propositions

[1] 'Traité des Variations des Os de la Face de l'Homme et leur signification au point de vue de l'Anthropologie Zoologique,' par M le Dr. A. F. Le Double, Paris, Vigot Frères, 1906.

has been refuted. He dwells very justly on the correlation of malformation (or perhaps merely variation) and disease. In his conclusions at the end of the work there is much that is interesting. He is severe on Lombroso. In fact, it is easy enough to demolish the fantastic exaggerations of that school; but we are not yet convinced that the idea of a criminal type is absurd.

Dr. Le Double writes as follows concerning variation: "In the actual conditions of our methods of investigation no truly scientific theory of heredity seems to me possible. There is not one of the explanations proposed to us that is not to some extent a matter of discussion." This is true and well said. We incline to think that he is rather too ready to accept the very general view of atavism. If a peculiarity is inherited we have a right to ask for the line of descent, and this line must not diverge from the lines used to explain other peculiarities. In point of fact this has not yet been shown. On the contrary, the threads tend to get snarled very badly.

We had not meant, however, to go into any discussion. Ours is the pleasanter purpose of calling attention to the thoroughness of the analysis and the wealth of material to be found in this book. None but a trained anatomist has any suspicion of the vast number of variations found in the bones of the face. We cannot even begin to enumerate them. Suffice it to say that the book is indispensable to the anatomist working in this department of science. The opening chapter on the nasal bones is a very attractive one. Then comes the chapter on the lachrymal, from which we would extract a table as a very striking illustration of the necessity of large series for statistics. The table shows the cases of absence of this bone seen by different observers:

Krause,	8 in	100 skulls.
Macalister,	2 in	150 skulls.
Bianchi,	5 in	350 skulls.
Merkel and Kallius,	1 in	1,000 skulls.
Zabel,	3 in	200 skulls.
Adachi,	6 in	121 skulls.
Le Double,	1 in	100 skulls.

It is to be noted that Adachi's observations were on Japanese. This raises the further question of the effect of race on variation. The whole subject is a very fascinating one.

THOMAS DWIGHT

Amerikanisches Hochschulwesen. Eindrücke und Betrachtungen. By Dr. W. BÖTTGER, Privatdozent at the University of Leipsic. Pp. 70. Leipsic, Wilhelm Engelmann. 1906.

This little book is a critical comparison of the conditions in American and German universities and schools for higher education, and is written especially with the aim of presenting to German readers that which is of merit in American institutions. The author's experience was gained by one year's residence in America, during which time he occupied the station of research associate at the Massachusetts Institute of Technology. By nature and training a keen observer and student of conditions, he has gained a remarkably thorough appreciation of the methods and ideals of American higher education as typified in the Massachusetts Institute of Technology and Harvard University. As he himself emphasizes, he has not immediately embodied his ideas in print, but has first allowed them to mature during several months after his return to his work in his native country. He thus can give a fairer survey of the subject and not one distorted by the accidental being mistaken for the typical, as has been done by some who have essayed to express themselves upon this subject.

America is, according to Dr. Böttger, the land of experimentation in educational matters; it is only during the last thirty years that the American universities have developed to their present importance. Their life is, therefore, younger and thus more energetic.

The length of time occupied in the preparatory schools by the youth of both countries is about equal—an average of twelve years; yet the graduate of the American preparatory school has only the training requisite for entrance to the highest class of the German 'gymnasium.' The reason for this is, naturally, that the American boy is not so severely pressed in his studies, whereby more oppor-

tunity is given for his very essential physical development.

The first years of the American college are still in the nature of preparation for his special line of study; thus the transition from a condition of dependence in the preparatory school to one of independence in the higher school is a gradual one. Much stress is laid by the author upon the American system of supervision of the students' work as compared with the German system of complete freedom. The advantages of the American method are evident—that many students are guarded against mistakes which would entail serious consequences. Contrasted to this, the German system suddenly throws the student wholly upon his own responsibility—upon entrance into the university his choice of studies is unrestricted, and he takes no examination until his final one, when he deems himself prepared to try for the degree of 'doctor' from the university. The German contends that his system possesses the advantage that those who do not make the proper use of the freedom accorded to them will sooner or later fall out, so that only those will reach the goal who properly understand the privileges and duties of the students' freedom. This argument, however, presupposes that the student already has that which he must first acquire. In America, the same goal is striven for, but with fewer losses, in that the transition to the condition of independence is made gradual.

The difference in the ideals of education in the two countries may be summed up in the following: In America the aim of the higher education is to increase the efficiency of the average man; while in Germany the stress is laid upon bringing the best to the highest development. The author seems to reach the conclusion that due precaution is exercised in America to prevent the invasion of the less diligent into the ranks of the learned professions, while, at the same time, pains are taken to develop the less gifted, who are, on this account, the more in need of education.

The author discusses at some length the matters of state and private schools, the organization of instruction, the cost of instruction and scholarships, athletics and the love and loyalty of the alumni of a school for their alma mater. Many matters of interest are treated which can not be touched upon in this review. The author has dealt very lightly with our failings and has devoted himself chiefly to pointing out to his countrymen, with whom education is an established science, that which has been attained in a country where education is still in the state of development. It is a matter of interest to learn those points in our system which are deemed commendable, or worthy of study, by a student trained in the old world educational ideals. This work is of additional interest as treating the subject especially from the viewpoint of education in the exact natural sciences; previous writers in the main having treated the subject in its relation to general culture.

Arthur A. Blanchard

SCIENTIFIC JOURNALS AND ARTICLES

The Journal of Geology for November–December has for its frontispiece a reproduction of a photograph of the late Professor Israel C. Russel. The first article is a sketch of his life by G. K. Gilbert. Following this is an article by James Geikie, "On the so-called 'Postglacial Formations' of Scotland." In this are discussed geographical and climatic changes, from evidence gathered in the Scottish mountains. As the most representative deposits known as 'postglacial,' he speaks of 'raised beaches, estuarine and fluviatile terraces, lacustrine alluvia and peat mosses.' He considers the term 'postglacial' misleading, because glacial conditions disappeared from different regions at widely different times. The following succession of events is given: (1) after the disappearance of district ice-sheets and mountain-valley glaciers, the sea retreated considerably, and the climate became milder; (2) subsidence and return to cold climate; (3) retreat of sea beyond present coast line and return to dry genial conditions; (4) partial subsidence with change of climate to cold and wet; (5) final retreat of sea to present level. The next article is on 'The Three Paleozoic Ice Ages of South Africa,' by Ernest H. L. Schwarz. Evidence is offered

of three ice ages at widely separated times. The Permian glaciation is already fairly well known. Of the other two, one is probably Devonian, the other Archean. The field evidence is said to be convincing. 'The Texture of Igneous Rocks' is taken up by Whitman Cross, J. P. Iddings, L. V. Pirsson and H. S. Washington. They attempt to make the classification according to textures more systematic, and to get rid of the prevalent vagueness and inexactness. Terms with exact meanings are proposed and the whole put into systematic shape. 'Natural Mounds' is the title of an article by Maurius R. Campbell. The mounds occur on flat surfaces and are low and broad, and very symmetrical. They vary from 10 to 140 feet in diameter and from a few inches to 5 or 6 feet in height. They are of very wide occurrence. Various hypotheses of origin have been offered, but many of them have little foundation. Of eleven possible modes of origin the writer eliminates all but the one which ascribes them to burrowing animals—ants or rodents. The subject of 'Rock Folds due to Weathering' is taken up by the same author. He shows how great the expansion is in ordinary weathering and how this often forces the surface rocks to buckle. 'The Geology of the Lower Amazon Region' is based upon Katzer's work and that of some others and was written by Charles Schuchert. As the title indicates, it is a discussion of the general geology and stratigraphy of the region and adds considerably to our knowledge of Brazil. The Devonian and Carboniferous are discussed in considerable detail, and lists of fossils given for correlation. The last article is by George Davis Louderback on 'The Relation of Radioactivity to Vulcanism.' The important bearing of the recently developed knowledge of radioactivity on the problems of the geologist is shown and discussed in some detail. The writer believes that while much of the interior heat of the earth may be explained by radioactivity, the special phenomena of volcanoes may not be so explained.

The Journal of Comparative Neurology and Psychology for November contains the following articles: 'The Mode of Connection of the Medullated Nerve Fiber with its Cell Body,' by Oliver S. Strong. A plate is given illustrating the form of the axone between the cell body and the medullary sheath. 'On the Centers for Taste and Touch in the Medulla Oblongata of Fishes,' by C. Judson Herrick. Fishes like the catfish which detect their food by the simultaneous action of both taste and touch in the barblets and outer skin offer an interesting problem in the examination of the centers of correlation within the brain for these diverse sensory tracts coming from the same cutaneous areas. The analysis of these centers in the medulla oblongata of Ameiurus shows that the gustatory nerves from visceral surfaces effect the usual secondary connections with the visceral musculature, but those gustatory nerves which come from the outer skin make their secondary connections with the primary tactile centers in the funicular nuclei, so that a common efferent path from the latter correlation center serves for both senses. 'Modifiability of Behavior in *Hydroides dianthus* V,' by Ada Watterson Yerkes. The experiments show that this annelid worm readily learns by experience. Two short papers on the 'Behavior of *Gonionemus*' are contributed by Max Morse and Robert M. Yerkes respectively. An editorial on the relation of the newer work of the American school of comparative neurologists to human neurology and a few book reviews complete the number.

SOCIETIES AND ACADEMIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

AT the 182d meeting of the society on November 14, Mr. F. E. Wright presented informally the results of a comparative study of various methods in use for determining the relative quantities of mineral constituents in rocks.

The meeting was devoted to an account of the Tenth International Geologic Congress, held in Mexico City, September 7 to 14, 1906.

Mr. GEORGE OTIS SMITH described 'The Excursion before the Congress.'

Mr. S. F. EMMONS: 'The Excursion to Jorullo.'

Mr. G. F. BECKER: 'The Sessions in Mexico City.'

Mr. T. W. STANTON: 'The Excursions after the Congress.'

At the 183d meeting of the society, held on November 28, Mr. Geo. H. Ashley exhibited a diagram illustrating the occurrence of contorted shales lying below a massive sandstone in relatively flat-lying rocks, suggesting that this effect may have been produced by the action of gravity subsequent to erosion. Mr. M. R. Campbell and Mr. G. C. Martin expressed the opinion that such structures are more likely to have originated as a result of folding prior to the deposition of the overlying strata.

Mr. Geo. B. Richardson exhibited specimens of fossil bones collected in October, 1906, at Rous' gravel pit in the northern part of El Paso, Texas. The remains, comprising teeth of a mammoth and a horse and the jaw bones of a tapir, had been secured and identified generically by Mr. Walter Koch, who presented them to the speaker. They have since been determined by Mr. J. W. Gidley of the U. S. National Museum to represent the following forms: *Elephas columbi, Equus complicatus* and *Tapiris* (*haysii?*). The bones were found in cross-bedded sand and gravel at two horizons, thirty and sixty feet below the surface of a hill, an erosion outlier of the bolson plain which lies at the base of the Franklin Mountains.

The find is of particular interest because it indicates the age of at least part of a great mass of unconsolidated beds adjacent to the valley of the Rio Grande, and furnishes another link in the long chain of evidence of a moist climate during the early Quaternary in the Cordilleran region. Deep well records show the presence of over 2,200 feet of unconsolidated material in the vicinity of El Paso, but whether all of this is Quaternary or the basal part is Tertiary remains to be determined.

In the discussion Mr. W. T. Lee mentioned the occurrence of the teeth of a Pleistocene species of *Equus* thirty miles northwest of El Paso, in beds formerly called Miocene, and Mr. C. A. Fisher reported similar fossils from the Pecos Valley.

Regular Program

The Geological Map of North America: Mr. Bailey Willis.

This map will be issued with the Comptes Rendus of the International Geological Congress held in Mexico City, September 7 to 14, 1906. It is further planned by the U. S. Geological Survey to issue a revised edition with descriptive text.

The Elevated Beaches of Labrador: M. L. Fuller.

The speaker reviewed the work of Bell, Packard, Low and Daly on the raised beaches and terraces of the Labrador coast, noting the doubt which a recent trip threw upon certain postulations of change of level based on some of the beaches and terraces. Some of the sea caves appear to be the result of weathering agencies rather than of marine erosion, while a great majority of the rock benches are manifestly due to differential subaerial erosion controlled by normal and concentric jointing and modified by glaciation. The preponderance of the beaches along the sides of the fiord-like inlets, and their eastward slope in certain instances, lead the speaker to consider some of them, at least, to be possibly due to causes other than marine erosion, representing, for instance, accumulations of the morainal terrace type along the sides of valley ice lobes during the closing stages of the last ice invasion. The method employed by Daly—the determination of the lowest limit of undisturbed glacial erratics—is recommended to future investigators as a more reliable means of determining changes of level than observations on the so-called beaches.

The Colorado Desert and Salton Sea. M. R. Campbell.

Discussed from the standpoint of engineering by Mr. E. W. Parker.

At the 184th meeting of the society, held on December 19, Mr. George P. Merrill, the retiring president, presented an address, illustrated by lantern slides, entitled "The Composition and Structure of Meteorites compared with those of Terrestrial Rocks."

At the close of Mr. Merrill's address the fourteenth annual meeting of the society was held for the purpose of electing officers, and the following officers were elected for the ensuing year.

President—Mr. Waldemar Lindgren.

Vice-Presidents—Mr. M. R. Campbell, and A. H. Brooks.

Secretaries—Messrs. F. E. Wright and Ralph Arnold.

Treasurer—Mr. Joseph A. Taff.

Members at Large of the Council—F. L. Ransome, T. W. Stanton, George H. Ashley, E. O. Ulrich, George B. Richardson.

ARTHUR C. SPENCER,
Secretary

DISCUSSION AND CORRESPONDENCE

THE CARNEGIE FOUNDATION

TO THE EDITOR OF SCIENCE: I am sorry to conclude, after a perusal of the last number of SCIENCE that has reached me (October 26, 1906) that everything is not going just right everywhere just now. My grief is greatly softened, however, by the fact that the columns of that always instructive and sometimes entertaining journal seem to be pretty 'wide-open' to people who 'object.' I can hardly tell what a boon this will be to some of us whose activities are now mostly restricted to some form of mild and, I trust, inoffensive 'kicking.'

I have been waiting for some months for somebody to enter a protest against the phraseology of the published notices of the awards of pensions from the 'Carnegie Foundation for the Advancement of Teaching.' As the same 'peculiar wording' has been used in every such notice that I have seen, I infer that it must have been purposely selected and formally adopted by some one. 'The retirement of Professor ——— *is made possible*' (the italics are mine) by the action of the trustees of the Carnegie Fund, etc.

When I first read this phrase in the announcement of Dr. Harris's retirement from the Bureau of Education I thought it only an amusing oversight, a bit of ill-considered composition, or a case of 'the types made us say'; but when I read it later of Professor Morley and again of Professor Dolbear (I think) I saw that some other than the printer's devil was having a hand in it. For in my humble and far-away judgment the italicized words, as applied to the retirements named above, are about the most infelicitous that a diabolical ingenuity could select. To one who doesn't know the man or his work, or the big place he fills in the 'educational heart' of the great republic, the words clearly imply that the president, and everybody else, for that matter, have been wanting for years to retire Dr. Harris, but that it was impossible to get rid of him until the Carnegie fund came to the rescue. One must conclude that through the same beneficent charity Western Reserve University is now relieved of Professor Morley, the most distinguished member of its faculty; and that Tufts breathes again, free from the incubus of Dolbear. I am not holding the trustees of the Carnegie fund responsible for these words nor am I questioning their singular appropriateness in *the majority of cases with which the trustees will have to deal*, but to the inventor of the phrase, whoever he may be, I submit that there ought to be an alternative, for use when the above seems to be not just the right thing to say—something that will not mislead the intelligent but uninformed reader.

About a quarter of a century ago it was my pleasure to sit through several sessions of the physical section of the British Association, presided over by Lord Kelvin. Following the usual English practise, he always said a few words after the presentation of each paper, conveying the thanks of the section to its author. The custom is often purely formal and generally the words have little real meaning, but it was delightful to see that the distinguished chairman, following his natural leaning towards 'precision,' had devised two expressions, quite similar in form but, to a reflective listener, very different in meaning, which he made use of as judgment dictated, in the discharge of this part of his duty as presiding officer. In one case he would say, "I am sure the section will join me in thanking Mr. ——— for his most interesting and important communication on this subject," while in another it would be, "I am sure the section will join me in thanking Mr. ——— for his communication on this *most interesting and important subject.*"

Can not the editor of the Carnegie pension

announcements evolve something like this?—and then everybody will be happy.

T. C. M.

DRESDEN,
November 12, 1906

IS THERE DETERMINATE VARIATION?

PROFESSOR KELLOGG has presented some very interesting facts and arguments regarding the variation of *Diabrotica soror,* under the above title (SCIENCE, November 16, p. 621); but I venture to think that the dilemma has more horns than he has credited to it.

He shows (Fig. 7) that the Sierra Morena collection contains a very large proportion of fused-spots specimens. This material is from a locality about three miles from Stanford University campus. Now why is it not possible that a distinct Sierra Morena strain exists (perhaps the prevalent form of higher levels throughout the region), and that this has in recent years invaded the campus of Stanford University? If this is likely, or even possible, the whole matter may assume a different aspect.

If there exist different strains of *D. soror,* some free-spotted and some with a prevalence of fused spots, it is altogether likely that they differ in other characters, *e. g.,* power of resistance to particular forms of disease. If, in certain parts of the world, people with light complexions have supplanted those with dark, we are not obliged to assume that complexion is in itself a common cause of survival, or else abandon the idea of selection. We know, on the contrary, that the familiar color-characteristics accompany many others, some of which, singly or in combination, may have a high selection-value.

T. D. A. COCKERELL

UNIVERSITY OF COLORADO,
BOULDER, Colo.,
November 18, 1906

SPECIAL ARTICLES

THE ADVANCING MALASPINA GLACIER[1]

THE Malaspina Glacier lies at the seaward base of Mount St. Elias in Alaska, where a number of large valley glaciers descend from the St. Elias Alps, and coalesce at the mountain base to form a great ice plateau some fifteen hundred square miles in area. The characteristics of this piedmont ice plateau, the Malaspina Glacier, have been made known to us mainly through the splendid work and descriptions of the late Professor Russell.[2]

One of the striking features of the Malaspina Glacier, as described by Russell and others, was its smooth surface due to the general absence of crevassing. So well developed was this characteristic that the glacier has served as a highway of travel for a number of expeditions having for their object the ascent of Mount St. Elias. Twice Russell himself used the Malaspina for this purpose; Prince Luigi Amedeo, Duke of the Abruzzi, made use of the same highway on his successful ascent of St. Elias; and Mr. H. G. Bryant also traveled across the glacier toward Mount St. Elias. Each of these expeditions crossed the Malaspina Glacier on the side toward Yakutat Bay where my studies have been carried on. Other expeditions have crossed the glacier further west. In these expeditions it was found possible not only to move freely over the ice, but also to draw loaded sleds across it.

A second characteristic feature of the Malaspina Glacier is the presence of a moraine-veneered margin, developed by melting of the ice and concentration of the included rock fragments at the surface. In places, this veneer of moraine soil is so thick, and the ice under it so stagnant, that forests have developed upon it.

In the summer of 1905 I looked down upon the Malaspina Glacier from several high points in Yakutat Bay; and late in August

[1] Published by permission of the director of the United States Geological Survey. I wish to acknowledge in this work the assistance of Lawrence Martin and B. S. Butler, in 1905, and of the latter, together with O. VonEngeln, J. L. Rich, and R. R. Powers, in 1906. A paper, with photographs and map illustrating the changes described below, will appear in the forthcoming number of the *Bulletin* of the Geographical Society of Philadelphia.

[2] *Nat. Geographic Mag.*, Vol. III., 1891, pp. 53–204: Thirteenth Annual Report U. S. Geol. Survey, 1891–2, Part II., 1893, pp. 1–91.

two of my associates, Lawrence Martin and B. S. Butler, made an expedition to the western margin of the Floral Hills, where they had a clear view, and took photographs of the eastern margin of the Malaspina Glacier. At that time no unusual conditions were noticed.

In the summer of 1906, I made a second expedition to Alaska, having for its object the crossing of the Malaspina Glacier from east to west. It was my purpose to follow Russell's route as far as the Marvine Glacier, crossing it about where he did, then cross the route of Prince Luigi and Mr. Bryant, and proceed thence westward to the western margin if possible, in the meantime making side trips up the tributary glaciers and to various parts of the margin of the Malaspina.

This plan was most unexpectedly interfered with. The Marvine Glacier, which in 1890 Professor Russell crossed with ease, carrying his entire mountain-climbing outfit, was transformed from a smooth ice surface to a labyrinth of crevasses, across which we found it totally impossible to carry supplies. Even the passage of the glacier unburdened would have been a task which no one short of expert Alpinists could attempt; and I doubt very much if even they could possibly cross the glacier from side to side.

The evidence of our photographs of 1905, and of the views which we had from the neighboring mountains, clearly demonstrate that this remarkable change in the glacier has occurred since August, 1905. In 1906 we passed along the eastern margin of the Malaspina Glacier from the point of emergence of the Marvine Glacier from its mountain valley west of Blossom Island down the Kwik Valley to the sea. Thence southwestward along the shores of Yakutat Bay to Point Manby we saw the ice front from a boat. During his retreat in 1891, Professor Russell traveled freely from Point Manby to the Kwik River along this seaward margin of the glacier. Now it is impassably crevassed throughout the entire distance.

As we passed along the margin of the glacier, we found abundant evidence that the forward movement which has broken it is still in progress. The ice was even then being broken into blocks; ice fragments were falling from its face; moraine was tumbling down the front and into the crevasses; new streams were emerging from the moraine-covered front; and during the interval of a month which elapsed between our traverse up the glacier margin and our return, there were numerous changes in detail.

In places where the moraine on the glacier was occupied by forest, the crevassing had greatly disturbed the tree growth. The trees, some of which must have been at least fifty years old, stood at all angles and were frequently seen to fall down the ice front and into the crevasses. That the ice movement was wholly of the present season was proved by the fact that all the overturned trees had developed leaves before the disturbance affected them.

By this advance of the Marvine tributary to the Malaspina Glacier, the eastern portion of this piedmont glacier has been transformed to a sea of crevasses. The crevassed area starts with the width of the Marvine Glacier at its emergence from the mountain valley, but expands toward the sea into a bulb-shaped area of crevasses which includes the entire portion of the Malaspina Glacier bordering upon Yakutat Bay. Thus the crevassed area cuts across the routes followed by Bryant and Prince Luigi, so that at the present time a journey to Mount St. Elias from their point of starting (the Osar River) is out of the question.

We were unable to closely examine the tributaries of the Malaspina Glacier west of the Marvine; but from a distant view it is evident that no such disturbance as that caused by the advancing Marvine Glacier is present to the westward, as far as one could see. The Seward Glacier, next west of the Marvine, is, however, badly crevassed near the point of its emergence from its mountain valley; and one of my party, Benno Alexander, who was with Prince Luigi, asserts that it is far more broken than in 1897. Whether this represents the beginning of an advance similar to that of the Marvine can not now be stated.

The Hayden Glacier, which joins the Malas-

pina just east of the Marvine, shows no notable change from its condition in 1905; nor does the Lucia Glacier, which is the next glacier east of the Hayden, and which at the present time does not quite join the Malaspina. The glacier next east of the Lucia, however, has entirely changed its condition since we saw and crossed it in 1905. This glacier, the Atrevida, was crossed by Professor Russell on his first expedition in 1890. In August, 1905, we made several trips to its margin and one out upon it, while Messrs. Martin and Butler crossed it from side to side on their way to the Floral Hills. Where we crossed the Atrevida, in 1905, it was an undulating, moraine-veneered, apparently nearly stagnant glacier which could be crossed with great ease, and at all points, entirely without danger from crevasses. It was our intention to enter upon the Malaspina Glacier along this route; but, to our astonishment, we found that in ten months, between August, 1905, and June, 1906, the conditions had totally changed. We were unable to ascend even the margin in 1906, and views from above the glacier, on both the east and west sides, prove it to be broken from side to side, and from far up its mountain valley down nearly to its terminus in the moraine-veneered, alder-covered, bulb-shaped expansion beyond the mountain front. In its lower portion the Atrevida coalesces with the Lucia Glacier and thus we have the anomaly of two glaciers side by side, one of which shows no change, while the other is absolutely different from its condition only ten months before.

There are a score or more notable glaciers in Yakutat Bay, all but two of which are essentially as they were in 1905. Of these two exceptions one lies in a small mountain valley immediately north of the Turner Glacier. In 1905, this small valley glacier was apparently stagnant at its end, which was approximately a quarter of a mile back from the coast. Ten months later, in June, 1906, this unnamed glacier, which we will call the Haenke Glacier, was found to have advanced well out into the fiord, and to have joined the ice cliff of the Turner Glacier. By this addition the ice cliff of Turner Glacier is lengthened fully a mile. The Haenke Glacier was also profoundly crevassed during its forward rush. There is a glacier similar to the Haenke in the valley next north of it, and less than a mile distant, which shows no change from its condition in 1905.

The great Hubbard Glacier is the next in the fiord and it shows no change; but just east of it is a small glacier, which we named the Orange Glacier, in 1905, and over whose bulb-shaped terminus we walked freely, paying special attention to it because of an interesting series of concentric colored moraines which then covered it. We also walked up this glacier some five or six miles in a half day, and in that distance found no undue crevassing. In June, 1906, on the other hand, this glacier was crevassed from as far up the valley as we could see (about the point we reached in 1905), well down into its bulb-shaped terminus, which was shoved up much higher than in the previous summer. Its surface is so broken that in 1906 we were not able to even approach the colored moraine area over which we walked so easily in 1905. In the place of this moraine covered area of 1905 was clear, crevassed and pinnacled ice.

These facts prove that some of the glaciers of the Yakutat Bay region have been subjected to a paroxysmal thrust of great force. The thrust has been sufficient to break the glaciers not only in their mountain valleys, but also far down in their hitherto nearly stagnant bulb-shaped termini. In the case of the Marvine Glacier, the crevassing extends a distance of at least twelve or fifteen miles. Other glaciers, even those that are the nearest neighbors to the advancing tongues, have not yet been subjected to this forward thrust.

This is not the place to fully discuss the cause of this striking and unique change in the glaciers. Suffice it to say, that in seeking for a cause, we have felt obliged to discard the operation of normal climatic variations. It happens that in 1899 this region was visited by a series of exceedingly severe earthquake shocks during which the coast line in Yakutat Bay was greatly deformed, in one place being uplifted forty-seven feet. The hypothesis which we advance in explanation

of the changes briefly outlined above, is that during this, or possibly some previous earthquake, vast quantities of snow and ice were shaken down from the mountains upon the gathering grounds of these glaciers, starting a wave of advance whose thrust is now being felt by some of the glaciers, the thrust being sufficiently powerful to crowd forward and break up even the nearly stagnant termini. The selective action of this process, by which some of the glaciers are caused to advance and others not, may be only apparent, for it is possible that the wave of advance has not yet affected glaciers which will ultimately begin to move forward. It is highly probable, however, that in some instances the supply ground of the glaciers did not have conditions favorable to the large accession of snow necessary to cause a rapid crowding forward.

The future progress of this interesting phenomenon should be carefully watched. In order to discover and definitely prove its cause, we need to have a series of observations extending through successive years to see what happens to those glaciers which have just advanced, and to determine whether other glaciers are influenced in the same way, and exactly how they are affected. There is no region of active glaciers known to me which promises to yield more important results than this, if carefully watched for the next few years.

RALPH S. TARR
CORNELL UNIVERSITY,
ITHACA, N. Y.

SCIENTIFIC NOTES AND NEWS

DR. EDWARD L. NICHOLS, professor of physics in Cornell University, has been elected president of the American Association for the Advancement of Science for the meeting to be held next year at Chicago. The New York meeting, held from December 27 to January 1, under the presidency of Dr. W. H. Welch, professor of pathology in the Johns Hopkins University, has had no equal in size and probably no parallel in its service for the advancement and diffusion of science. The full report of the general secretary will be printed in the next issue of SCIENCE, and reports of the proceedings of the national scientific societies which met in affiliation with the association will follow.

THE council of the British Association has now appointed the presidents of sections for the meeting of the association to be held at Leicester next year. Of Section A (mathematical and physical science) the president will be Dr. Love, Sedleian professor of natural philosophy at Oxford; Section B (chemistry), Professor A. Smithells, professor of chemistry in the University of Leeds; Section C (geology), Dr. J. W. Gregory, professor of geology at Glasgow; Section D (zoology), Dr. W. E. Hoyle, keeper of the museum in the Victoria University, Manchester; Section E (geography), Mr. George G. Chisholm; Section F (economic science and statistics), Professor W. J. Ashley, dean of the Faculty of Commerce in Birmingham University; Section G (engineering), Professor Silvanus Thompson; Section H (anthropology), Mr. D. G. Hogarth; Section I (physiology), Dr. A. D. Waller, director of the Physiological Laboratory in London University; Section K (Botany) Dr. J. B. Farmer, professor of botany in the Royal College of Science; and Section L (educational science), Sir Philip Magnus.

PROFESSOR THOMSON, of Cambridge, M. Moissan, of Paris, Professor Golgi, of Pavia, and Professor Ramòn y Cajal, of Madrid, were present at Stockholm on December 10 to receive the Nobel prizes awarded to them.

DR. HENRY RUTGERS MARSHALL, of New York City, has been elected president of the American Psychological Association, and Dr. H. N. Gardiner, of Smith College, has been elected president of the American Philosophical Association.

MR. F. H. NEWELL, chief engineer of the Reclamation Service has been elected president of the Washington Society of Engineers.

GRAF VON ZEPPELIN, known for his work in aeronautics, has been given the honorary doctorate of engineering by the School of Technology at Dresden.

DR. ADOLF LIEBEN, formerly professor of chemistry at Vienna, has celebrated his seventieth birthday.

Professor E. Hersey Sneath has resigned the chair of theory and practise of education in Yale University owing to ill health.

The special board for biology and geology at Cambridge University has adjudged the Walsingham medal for 1906 to W. E. Agar, for his essay on 'Researches into the Embryology of the Dipnoi,' and to W. L. Balls, for his essay entitled 'Studies of Egyptian Cotton.'

Professor H. W. Fisk, formerly professor of mathematics at Fargo College, Fargo, N. D., Messrs. P. H. Dike, formerly of the U. S. Coast and Geodetic Survey, and E. H. Bowen, formerly instructor in physics in the University of Maine, are at present engaged in magnetic work under the auspices of the department of terrestrial magnetism of the Carnegie Institution of Washington.

Dr. H. E. Annett, professor of comparative pathology in the University of Liverpool, has gone to St. Vincent in order to study certain diseases of animals for the government.

Dr. Acland, having been appointed by the Royal Colleges of Physicians and Surgeons official visitor to the examinations of the Cairo Medical School, has left London for a few weeks in connection with the appointment.

Dr. von Lecoq, a scientific emissary of the Prussian government, has arrived safely at Srinagar, after making important excavations in Chinese Turkestan.

The Friday evening meetings of the Royal Institution of Great Britain will be resumed on January 18, when Sir Andrew Noble, Bart., F.R.S., will give an address on 'Fifty Years of Explosives.' On February 1 Sir Almroth E. Wright, M.D., F.R.S., will speak on 'The Methods of Combating the Bacteria of Disease in the Interior of the Organism.'

Dr. Edward J. Nolan, recording secretary of the Academy of Natural Sciences of Philadelphia, is engaged on a history of the Academy from its foundation in 1812. He is desirous of having access to any correspondence or documents, apart from the official records of the society, which may relate to its work, especially during the first half century of its existence. If such papers be confided to Dr. Nolan, they will be discreetly used and returned safely to the owners.

The Women's Medical Association of New York City will hold a memorial meeting at the Academy of Medicine on January 4, as a tribute to the memory of the late Dr. Mary Putnam Jacobi. There will be addresses by Dr. William Osler, Dr. Charles L. Dana, president of the Academy of Medicine; Professor Felix Adler, Mrs. Florence Kelley and others.

The death is announced of Mr. John Ward, a British geologist, known for his valuable work on the carboniferous faunas.

Dr. Ernst Pfitzer, professor of botany at the University of Heidelberg, has died at the age of sixty-one years.

The U. S. Civil Service Commission announces an examination on January 16, 1907, to fill a vacancy in the position of forest planting assistant, at $700 per annum, in the Forest Service of the Department of Agriculture.

The College of Physicians of Philadelphia announces that the next award of the Alvarenga prize, being the income for one year of the bequest of the late Senor Alvarenga, and amounting to about $180, will be made on July 14, 1907.

According to foreign journals, a wealthy landed proprietor named M. Audrac, who died recently at Le Luc, near Draguignan, has left the Pasteur Institute the whole of his fortune, valued at the equivalent of $250,000 at least. Interviewed on the subject, Dr. Roux, the distinguished director of the institute, stated that he had received a visit from a lawyer, who informed him that a will had been found bequeathing the whole of the property to the institute. The reserve, however, was made that another document might possibly come to light making various bequests or otherwise disposing of part or whole of the property; consequently, Dr. Roux says that some time must elapse before the Pasteur Institute can know definitely how it stands with regard to the inheritance.

The Magnetic Survey yacht *Galilee*, engaged in the magnetic survey of the Pacific Ocean under the auspices of the Carnegie

Institution of Washington, left San Diego, California, on December 22 on her third cruise, which will extend to the end of the year 1907 and will embrace about 25,000 to 30,000 miles. It was found necessary to defer the proposed circumnavigation cruise and instead to pursue a course indicated by the following ports of call: Nakuhiva (Marquesas Islands), Tahiti, Apia, Yap, Shanghai, Hongkong, Yokohoma, Honolulu, Dutch Harbor (Aleutian Islands), Sitka and return to San Diego, from which port it is possible that another circuit situated between the Galapagos Islands and Marquesas Islands may be undertaken. The vessel, as during the past year, is again commanded by Mr. W. J. Peters, who is assisted by Messrs. J. C. Pearson and D. C. Sowers, magnetic observers, and Dr. George Peterson, surgeon and recorder. The sailing master, as during the past two cruises, is Captain J. T. Hayes.

THE Vienna Geographical Society has celebrated the fiftieth anniversary of its foundation under the presidency of Archduke Rainer.

THE preliminary program of the second International Congress on School Hygiene, of which King Edward is patron, has been issued. The session will be from August 5 to August 10, 1907, at the University of London, South Kensington. The work of the congress will be divided into eleven sections, each presided over by an authority on the subject dealt with.

WE learn from *The British Medical Journal* that news has come from the Sesse Islands, Victoria Nyanza, of Professor Koch's expedition for the study of sleeping sickness. The expedition is divided into two parts. One, under the direction of Professor Koch himself, is working at Kion, the other, under Professor Beck, at Boumangi. Natives are said to be coming to both stations from the remotest provinces, the average number attending being some three hundred a day. Professor Koch, it is said, will publish nothing as to his method until he has had more definite results than have yet been obtained. The members of the expedition live in rooms destitute of the comforts of civilization, which serve as bedroom, dining room and laboratory.

WE learn from *The Athæneum* that Messrs. Heffer & Sons have purchased the mathematical library of the late Professor Joly, of Dublin, and the botanical library of the late Professor Marshall Ward, of Cambridge, catalogues of which are in preparation.

THE London *Times* states that the 52d annual dinner of the Society of Engineers took place on Wednesday night, December 12, at the Hotel Cecil. The president, Mr. Maurice Wilson, Assoc. M. Inst. C. E., was in the chair, and among those present were Sir Alexander Kennedy (president of the Institution of Civil Engineers), Dr. Glazebrook (president of the Institution of Electrical Engineers), Commander Caborne, C. B., Colonel L. Blakeney Booth, Mr. Maurice Fitzmaurice, Mr. R. St. George Moore (the president elect), Mr. J. W. Wilson (vice-president), Professor S. H. Cox, Mr. D. D. Butler (honorary treasurer), and Mr. Perry F. Nursey (secretary). Sir Alexander Kennedy, in proposing 'The Society of Engineers,' said that it was now the day of the engineers, and they had better make the best of it they could. Clearly the essential thing was that they should be as good engineers as they could, and one of the things which had helped them to be good engineers hitherto, and was helping them now, was their extraordinary tendency to form themselves into technical societies. One of the pioneers was certainly the Society of Engineers, which was third in age of the engineering societies, and which he hoped might live and flourish for many years to come. The president, in responding, said that their membership had increased during the past year, and their financial position was exceedingly sound, sounder, perhaps, than it had ever been. They had unfortunately lost their oldest honorary member, Sir Edward Reed, who was elected nearly thirty years ago and who was naval constructor about the time of the transition from wooden walls to armour-clad ships. Their ordinary meetings had shown an increase in their average attendance during the past year, and they had had read to them numerous interesting papers, not the least interesting of them being one by their indefatigable honorary secretary, who had con-

tributed his twenty-fourth paper to their transactions. Their members could be found all over the world, and included men of all nationalities. Mr. R. St. George Moore proposed the toast of 'Kindred Institutions,' for which Dr. Glazebrook responded, and the toast of 'Our Guests' was submitted by Mr. J. W. Wilson and acknowledged by Mr. Maurice Fitzmaurice.

In 1905 the total value of our mineral production was $1,623,877,127, as compared with $1,360,883,554 in 1904. As heretofore, iron and coal are the most important of our mineral products. The value of the iron in 1905 was $382,450,000; the value of the coal, $476,756,963. The fuels increased from $584,043,236 in 1904 to $602,477,217 in 1905, a gain of $18,433,981, or 3.16 per cent. Anthracite coal showed an increase in value of $2,904,980 from $138,974,020 in 1904 to $141,879,000 in 1905. The increase in value of the bituminous coal output over 1904 was $29,480,962, a combined increase in value of coal of $32,385,942 in 1905, or 7.3 per cent. The gain of $262,993,573 in the total value of mineral production is due to gains in both metallic and non-metallic products, the metallic products showing an increase from $501,099,950 in 1904 to $702,453,108 in 1905, a gain of $201,353,158, and the non-metallic products showing an increase from $859,383,604 in 1904 to $921,024,019 in 1905, a gain of $61,640,415. To these products should be added estimated unspecified products, including molybdenum, bismuth, tungsten, and other mineral products, valued at $400,000, making the total mineral production for 1905 of $1,623,877,127. Besides the usual table and summary of quantities and values of the country's mineral output by products, the volume contains this year, for the first time, a summary, in tabulated form, of the value of the mineral products by States. These tables were compiled by Mr. Wm. Taylor Thom.

UNIVERSITY AND EDUCATIONAL NEWS

New York University has received a gift of about fifteen acres of land adjoining the south line of its grounds and extending towards 180th Street. The value of the property is said to be between $200,000 and $300,000.

Mr. Andrew Carnegie has given to the College of Physicians of Philadelphia $100,000 towards the erection of its new building, on condition that a like sum be subscribed, of which $80,000 has already been received.

The department of archeology of the University of Pennsylvania has received a gift of $40,000 from Mr. Eckley Brinton Coxe, Jr. The donor has specified that of the gift $8,600 a year shall be paid for five years to the new curator of the department of Egyptology, Dr. D. Randall McIver, who is now in Egypt, where he has been instructed to begin excavations.

We learn from *Nature* that Gonville and Caius College, Cambridge University, having decided to close their chemical laboratory at the end of the present academic year, a syndicate was appointed on November 8 to consider the assignment of a site for the extension of the chemical laboratory. The conclusion arrived at is that, of the sites available, the one site which is not liable to considerable objection lies between the chemical laboratory and the new medical schools, with a frontage next Pembroke Street.

The University of Turin celebrated on October 27 the five hundredth anniversary of its foundation, this celebration having been postponed for two years, owing to the disastrous fire. In honor of the occasion a history of the university has been published.

Dr. William A. Noyes, head of the department of chemistry in the Bureau of Standards, and secretary and editor of the American Chemical Society, has been elected professor of chemistry in the University of Illinois.

The council of King's College, London, has appointed Mr. H. de Sadow Pittard, M.A., Ph.D., as assistant lecturer in mathematics, and Mr. A. W. Sikes, D.Sc., M.D., F.R.C.S., as demonstrator in physiology.